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Policy Options for Encouraging Energy Efficiency Best Practices in Shandong Province's Cement Industry

Exploring design options for a sectoral approach

Lynn Price, Nan Zhou, Hongyou Lu
China Energy Group
Environmental Energy Technologies Division
Lawrence Berkeley National Laboratory

Emiel van Sambeek, Ping Yowargana, Liu Shuang
Azure International

Jiang Kejun
Energy Research Institute

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Disclaimer

Preface

This project was implemented by Azure International in collaboration with the Energy Research Institute (ERI) of the National Development and Reform Commission (NDRC), Shandong Energy Conservation Office and Lawrence Berkeley National Laboratory with support from the UK government through the Strategic Programme Fund and the Energy Foundation's China Sustainable Energy Program. Sectoral mechanisms have been a much-discussed topic in international climate negotiations under the UNFCCC. The purpose of this project was to investigate possible designs of a sectoral mechanism, based on the concept of a sector no-lose target and crediting mechanism, for achieving ambitious GHG emission reductions in the cement sector in Shandong Province. The research conducted under this project is purely exploratory. The views expressed in this report do not necessarily represent the views of the funders, nor do they represent any official view by the Chinese government on sectoral approaches. For further information regarding this project, please contact Mr. Emiel van Sambeek at e.vansambeek@azure-international.com.

Acknowledgements

This report was drafted by Azure International, Energy Research Institute (ERI) of the National Development and Reform Commission and Lawrence Berkeley National Laboratory. The analysis of Shandong's cement industry would not have been possible without the support from Shandong Energy Conservation Office (SECO) as a partner in the project. Zhao Xudong, Zhu Hui and Diao Lizhang of SECO were part of the project team and provided inputs on data, carried out surveys, provided policy information, organized stakeholder workshops and provided their honest and invaluable feedback on all policy options reviewed throughout this project.

The project was funded by both UK government's Strategic Programme Fund (SPF) and the Energy Foundation's China Sustainable Energy Program (CSEP). The project also benefits from inputs on project design and content, provided by SPF and CSEP, particularly: Alan Searl, Lin Na and Luo Nan from SPF, Hu Min and Chen Lingyan from CSEP.

Miao Xin from Shandong Environmental Protection Agency, Zhang Huaigong from Jinan Energy Conservation Office, Xu Guangliang Jinan Environmental Protection Agency, Tian Lin from Jinan Municipal Administration & Public Utility Commission, Xu Xin from Zaozhuang Economy and Information Technology Commission, Tang Wei from Zaozhuang Environmental Protection Agency, Liu Tao from Zaozhuang Municipal Administration & Public Utility Commission, and Xiao Zicai, Pi Shihai from Zaozhuang China United Cement Company, have kindly offered their help during project interviews and surveys and provided useful information on Shandong's cement production situation.

Barbara Haya from the University California – Berkeley, as well as Ali Hasanbeigi of Lawrence Berkeley National Laboratory, and Stephanie Ohshita of the University of San Francisco (currently a Visiting Faculty member of Lawrence Berkeley National Laboratory's China Energy Group) have also contributed to developing the ideas on sectoral approach and its design. Appreciations go to their inspiring thoughts on how the sectoral approach can be realized.

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Executive Summary

The sectoral approach is a mechanism to organize "action by key product producers in a specific industry sector and their host governments to address the greenhouse gas emissions from their products and processes" (WBCSD, 2009). This research analyzes the concept of a sectoral "no-lose" target under which tradable emission reduction units would be issued for emission reductions beyond the agreed sector baseline. However, no penalty would apply in case the country failed to meet the target (therefore called "no-lose" target).

The process intends to strengthen government and national ownership over public sector policy and enhance the coherence among policy, spending and results (European Commission, 2007). It is also a recognized mechanism that works in conjunction with other policies and processes as elements of a comprehensive post-2012 climate framework.

This research intends to explore possible design options for a sectoral approach in the cement sector in Shandong Province and to consider its respective advantages and disadvantages for future application. An effort has been made in this research to gather and analyze data that will provide a transparent and robust basis for development of a Business-As-Usual (BAU) scenario, maximum technology potential scenario, and ultimately a sector crediting baseline. Surveys among cement companies and discussions with stakeholders were also conducted in order to better understand the industry and local needs related to the sectoral approach.

The research analyzes data from the cement sector in Shandong province and uses policy and technology assumptions to estimate both the BAU and maximum reduction scenarios. Figure 1 illustrates the scenarios. Once these scenarios are determined, a sectoral crediting baseline can be negotiated in the range of 526.2 and 598.2 kgCO_2/t of cement by 2020.

With the recent policy signals from the National Development and Reform Commission (NDRC) on the design of cap-and-trade systems, less progress could be made by local governments in exploring specific design options for a sectoral approach. However, these governments used this research to inform their thinking and their own research into policy design options for pilot cap-and-trade systems. The most concrete example of this is the use of the research results by SECO in developing its energy saving cap-and-trade pilot program in Yantai.

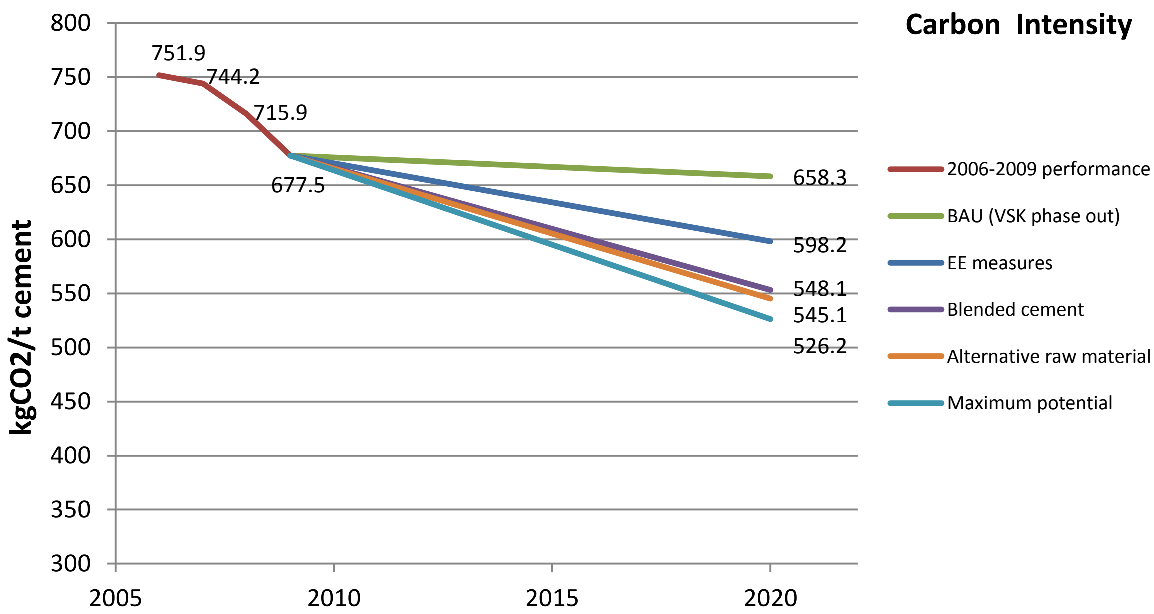

Figure 1 BAU and maximum potential scenario for Shandong cement sector (cement, carbon)

This research concludes that a sectoral approach could be implemented in Shandong's cement sector. However, further work is needed to fine-tune the specific crediting arrangements, MRV and institutional mechanisms, as well as defining the crediting baseline under such a sectoral approach. This research has laid out the options to inform such a discussion with an international trading partner towards establishing an actual sectoral approach project based on the sector no-lose concept in the cement sector in Shandong.

1. Introduction

A sectoral approach to energy savings or greenhouse gas (GHG) mitigation has been defined by the World Business Council for Sustainable Development (WBCSD, 2009) as:

> [O]rganized action by key product producers in a specific industry sector and their host governments to address the greenhouse gas emissions from their products and processes, within the UNFCCC [United Nations Framework Convention on Climate Change] framework. Specific actions taken would differ from sector to sector, dictated by the characteristics of each sector's structure and technologies. Actions would also differ from country to country, following the principle of common but differentiated responsibilities laid out by the UNFCCC.

The sectoral approach is a process aimed at broadening government and national ownership over public sector policy and increasing coherence between policy, spending and results (European Commission, 2007). The sectoral approach is recognized to work in conjunction with other policies and processes as elements of a comprehensive post-2012 climate framework. There are various sectoral approach proposals under international negotiation: the European Union's sectoral market mechanisms, New Zealand's National Appropriate Mitigation Action (NAMA) and Korea's NAMA crediting.

In 2009, Azure International and the Energy Research Institute (ERI), with funding from the UK Strategic Programme Fund, tested a Sectoral Proposal Template in China's electricity, cement and transportation sectors. This study used an existing template to develop various scenarios for each sector and to provide a basis for negotiating a no-lose target between two partner countries/regions involved in the trading of credits resulting from the GHG emissions reductions resulting from the use of a sectoral mechanism (Azure, 2009). The purpose of this study was not to propose specific sector no-lose targets, but rather to use a transparent method to demonstrate how such targets could be set and supported by relevant industry and policy analysis.

This initial research using Sectoral Proposal Templates in a Chinese context stimulated further interest to work to explore options to pilot test a sectoral approach in China. Shandong was chosen as a first potential pilot province. Shandong produces approximately 10% of China's cement and has an institutionally strong Energy Conservation Office that was interested in learning more about sectoral approaches. Furthermore, the California Air Resources Board was interested in working with Shandong to explore options for generating GHG emission credits through a sectoral mechanism that could be used as international offsets in the California cap-and-trade system that at the time was about to be created by Assembly Bill 32 (AB32): The Global Warming Solutions Act of 2006 (CARB, 2011). In this Bill international offsets were created as a policy option to help encourage energy and carbon reductions outside the state. Meanwhile, the European Commission also proposed the sectoral approach as a way of working with international partners to increase coherence between national policies, sectoral policies, resource allocation and spending practices (EU, 2007). As the interest in sectoral approach grew, the need to further refine the sectoral concept through close consultation with potential government partners and other stakeholders becomes more apparent.

Within this context, Azure International partnered with the Energy Research Institute (ERI) of the National Development and Reform Commission (NDRC) and Lawrence Berkeley National Laboratory (LBNL) in 2010 to explore possible design options for a sectoral approach in the cement sector in Shandong Province and to conduct analyses on their respective advantages and disadvantages. In close cooperation and consultation with the Shandong Energy Conservation Office (SECO) and cement companies in Shandong, interviews and discussions were conducted with SECO and companies to ensure design options reflected realistic institutional capabilities. The overall objective was to implement a sectoral approach in Shandong while meeting general international requirements on the credibility of the credits.

Although the research focused on a sectoral approach, the project team believes certain results such as the recommendations on specific design options can be useful beyond the immediate context of a sectoral mechanism. As the Chinese government is exploring the use of market-based instruments to encourage larger energy and carbon reductions in China, this research can also contribute to the on-going discussion and piloting of domestic flexible trading schemes.

Conducting policy research that aims to feed into a very dynamic policy context such as international climate policy discussions and Chinese energy and climate policy clearly requires flexibility. Over the course of this research, there was uncertainty regarding the course that the California cap-and-trade scheme would take with regard to international credits and the possibilities of developing a bilateral collaboration on the generation and purchase of such credits from the Shandong cement sector. The result of this was that many of the discussions on specific design options lacked focus and conclusions remained generic. In addition, during the project China completed its 11th Five Year Plan and started its 12th Five Year Plan. This had significant impact on the project as at the beginning of a new Five Year Plan little is known about disaggregated sectoral policy targets, the policy instruments that will be implemented and the institutional arrangement to implement these policies. This severely limited the ability of policy makers to provide feedback on the feasibility of design options that were explored during this research. However, much of the data analysis and policy design options that were reviewed in this research could also usefully inform the design of policies outside the immediate context of a sectoral approach the team adopted a flexible approach in interacting with policy makers to also address their interests in policy options other than a sectoral approach. Unfortunately, this has meant that it was not always possible reach definite conclusions on design options for a sectoral approach. This report therefore provides an overview of the work that was conducted in order to generate data, analysis and policy design results that allow Shandong and a potential future international partner to jointly negotiate a sectoral mechanism for the cement sector based on the sector no-lose target concept.

2. Sectoral approaches and critical design issues

A sectoral approach to energy savings or greenhouse gas (GHG) mitigation has been defined by the World Business Council for Sustainable Development (WBCSD, 2009) as:

> [O]rganized action by key product producers in a specific industry sector and their host governments to address the greenhouse gas emissions from their products and processes, within the UNFCCC [United Nations Framework Convention on Climate Change] framework. Specific actions taken would differ from sector to sector, dictated by the characteristics of each sector's structure and technologies. Actions would also differ from country to country, following the principle of common but differentiated responsibilities laid out by the UNFCCC

"A sectoral approach is a way of working together between government, development partners and other key sector stakeholders, aiming at broadening government and national ownership over public sector policy and resource allocation decisions, increasing the coherence between policy, spending and results, and reducing transaction costs" (European Commission, 2007). Under the UNFCCC, parties are considering "cooperative sectoral approaches and sector-specific actions, in order to enhance implementation of Article 4, paragraph 1(c), of the Convention" (Bali Action Plan, 2007). A wide range of activities has been identified as sectoral approaches, for instance, voluntary industry-to-industry initiatives, government-to-government sectoral commitments and policy-based approach (UNEP, 2009).

Our research analyzed the concept of a sector "no-lose" target as a potential design option for the sectoral approach. Under this design, developing countries pledge to achieve voluntary sector "no-lose" targets for certain sectors (e.g., cement, steel, power). Tradable emission reduction units would be issued for emission reductions beyond the agreed sector baseline. However, no penalty would apply in case the country failed to meet the target (therefore called "no-lose" target).

For Shandong's cement sector, the sectoral approach is a scheme providing support in addition to current policies and measures. A sector crediting baseline would be defined and agreed by both Shandong and international partners. Shandong's efforts leading to reductions below the crediting baseline would be rewarded by tradable credits. A sectoral crediting baseline falls between the Business-as-Usual (BAU) scenario and the maximum reduction potential.

A BAU scenario includes currently implemented domestic policies and measures, as well as existing external financial and technical support (see Figure 2). Both Shandong and international parties need to agree on what domestic policies that will come into place are recognized as additional to the BAU, thereby determining how close the crediting baseline is to BAU. Any further financial and technical external support under the sectoral approach will move the actual reduction below the crediting baseline.

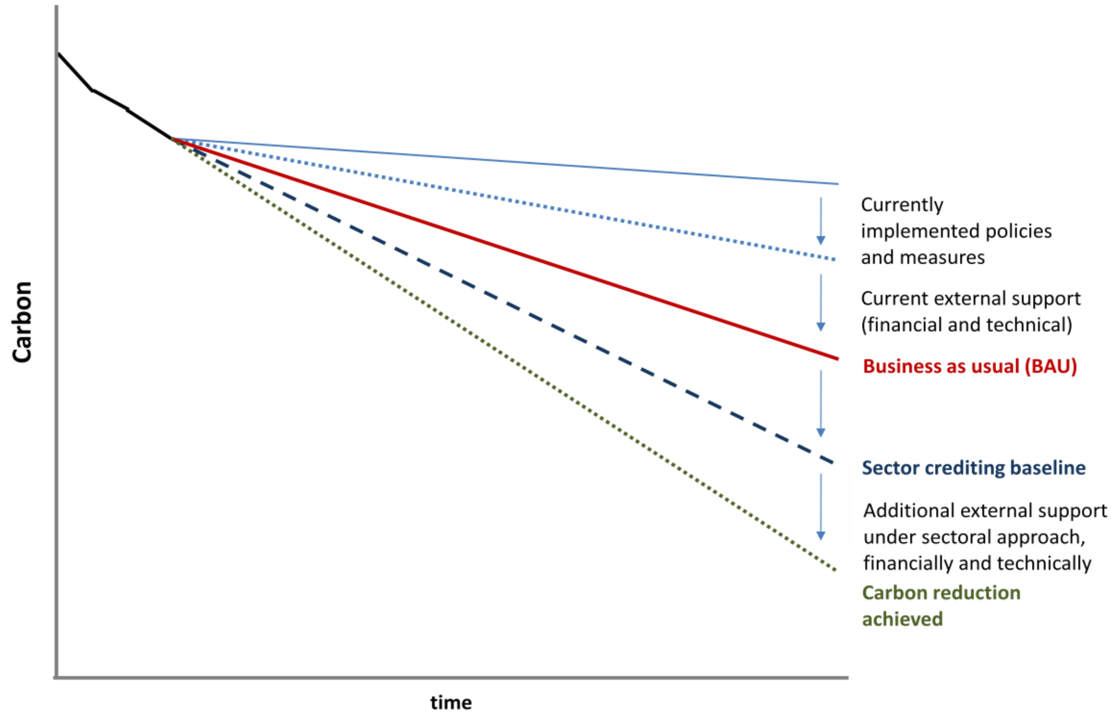

Figure 2 Sector No-Lose Target and the Sectoral Policy Package

There are four categories of measures which can be employed in Shandong's cement sector to aid in the reduction of carbon dioxide (CO_2) emissions or energy consumption from BAU: energy efficiency, alternative fuels, alternative raw materials, and other new technologies (see Figure 3). For each category, the closer it is to BAU, the more feasible it will be to employ in Shandong. Negotiation results between Shandong and international parties shall then determine the resulting crediting baseline.

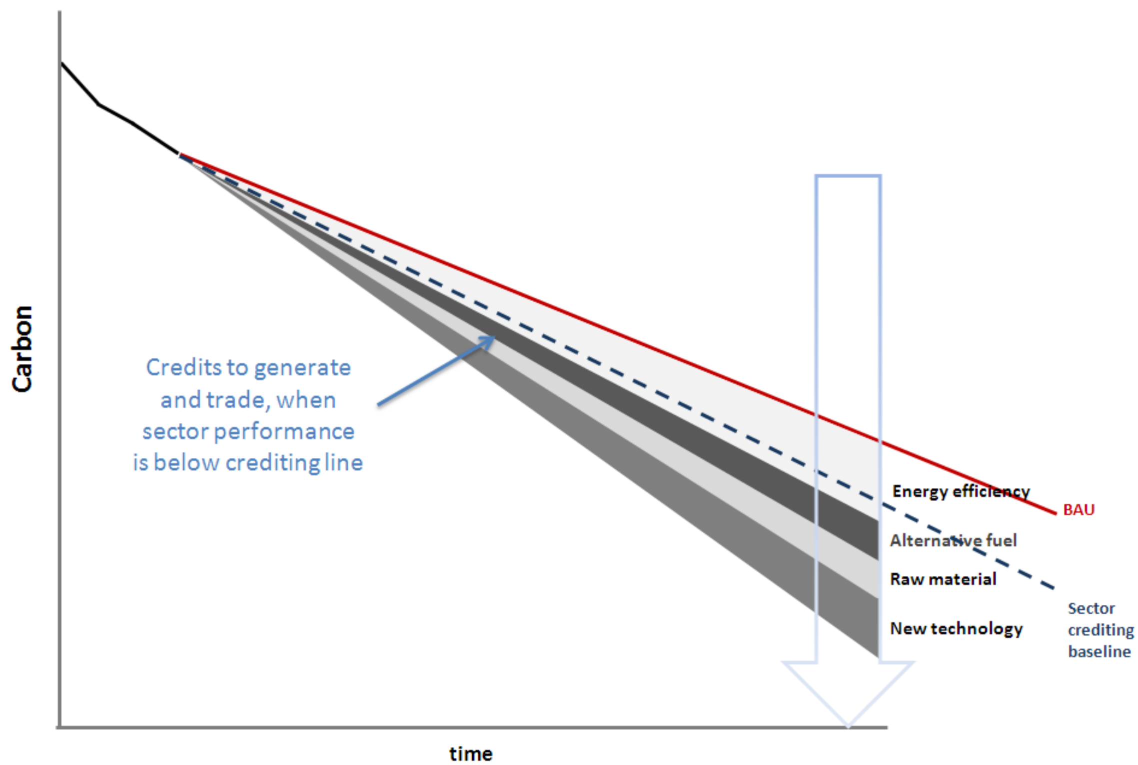

Figure 3 Sector No-Lose Target and the Sectoral Technology Package

Key design issues for a sector no-lose crediting mechanism are:

- To define the BAU and crediting baselines. These concepts define the carbon reduction and credit generating potential;
- To set up credit issuing mechanism, including clearly identifying how incentives for emission reductions would be passed on to emitters;
- To establish a measurement, reporting and verification (MRV) framework that is credible in an international context and matches the domestic context at the same time.

The above key design issues are further elaborated in the following chapters.

Boundary setting: cement or clinker?

Selecting appropriate parameters is critical in ensuring effective enforcement of energy efficiency policies. In a sectoral approach, parameter selection directly affects scenario establishment, the potential for generated credits, and operational issues related to MRV. Furthermore, for the cement sector, a choice needs to be made between cement and clinker as the calculation basis for the energy or carbon performance parameter.

Figure 4 illustrates the key steps in cement production. After the raw materials are quarried, ground, and mixed, they are pyroprocessed in large kilns to produce clinker. Clinker is then mixed and ground with additives to produce cement. Some plants only produce clinker, selling it to cement grinding facilities to produce cement. Other plants produce both clinker and cement. If the region being assessed has many plants that just produce clinker or if there is a significant amount of clinker importing and exporting, then it is preferable to use clinker as the calculation basis for the energy or carbon performance parameter since this is the only portion of cement making under the control of each facility. If facilities in the region being assessed do not participate in a significant level of clinker trade, then it is preferable to use cement as the calculation basis for the energy and carbon performance parameter since cement making also includes other actions, such as intergrinding other materials to produce differing levels of blended cement, that can reduce energy use and associated CO_2 emissions. Thus, assessing energy or carbon performance at the cement production level means more energy efficiency or carbon mitigation opportunities are incentivized within the policy package of a sectoral mechanism. In this research we have therefore used cement production as the boundary for analyzing mitigation options.

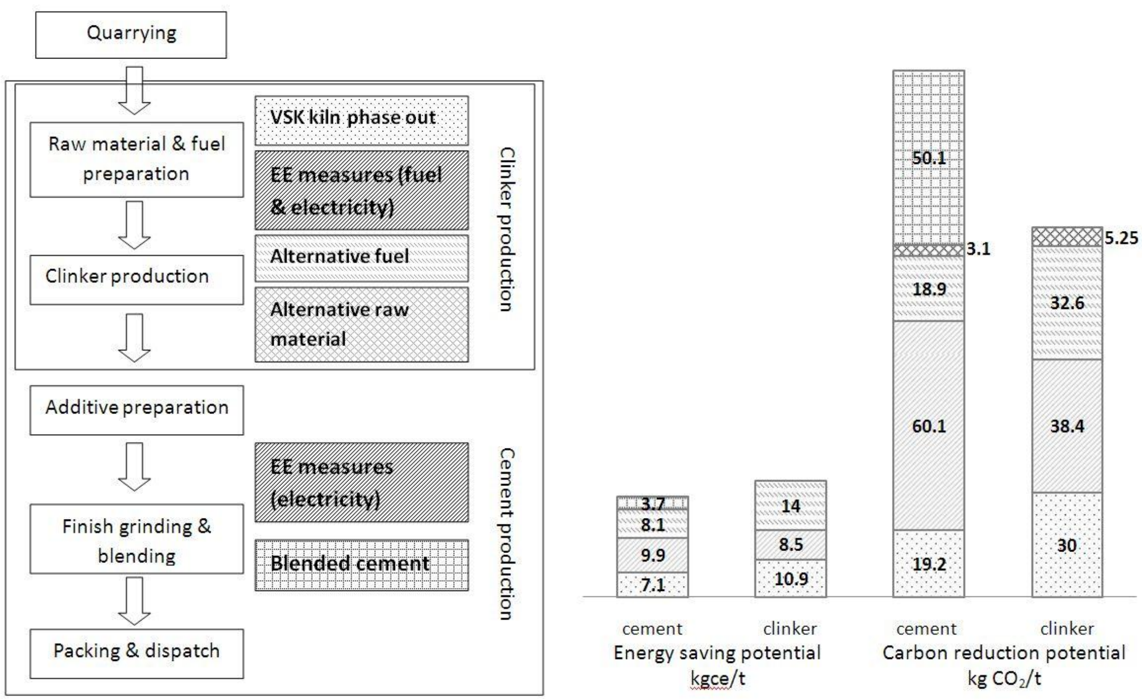

Figure 4 Energy saving and CO2 emission reduction potential of various measures for cement and clinker, 2009-2020

Note: results of maximum energy saving potential, data from project survey, see section 4.4

Figure 4 displays the energy saving and CO_2 emission reduction potential for the two different bases for calculation, demonstrating that there are more potential CO2 emissions reductions when calculations are made using tons of cement and when using tons of clinker (more description on the calculation process can be found in section 4.4).

3. Project Approach

A major portion of the research concentrated on data gathering and analysis to provide a transparent and robust basis for the BAU, maximum technology potential scenario and ultimately a sector crediting baseline. To obtain detailed data as a basis for developing the BAU and maximum potential scenarios, the project team collaborated with the Shandong Energy Conservation Office (SECO) to collect data on Shandong's cement sector. Historical data comes from Shandong Statistics Bureau and was cross-checked with the Shandong Cement Association's database. The team has also compared Shandong's data against China's national level data and international practices to ensure consistency.

Together with SECO, the project team conducted a survey on Shandong's cement companies to estimate potential for implementing GHG emission reduction technologies. The survey (see Appedix 4) covered half of Shandong's cement production capacity, and provides an indication of the industry's technology situation. To estimate the maximum reduction potential up to 2020, assumptions on policies and technologies were used from Shandong and national level expert consultations and literature on the cement sector's energy-saving technologies and potential.

Rounds of discussion were carried out with SECO, as they are envisioned as the major implementer for a sectoral approach project and other market-based instruments in Shandong. This effort organized workshops and roundtable discussions in May 2010, August 2010, March 2011, and May 2011. In May 2010, the team introduced the project to 22 managers from 18 cement factories, answered questions, and gathered preliminary feedback on the design options. In August 2010, the project team clarified expected project deliverables and agreed on an integrated work plan; latest updates on California's sectoral approach were also provided. In March 2011, the team presented estimated scenario and policy recommendations on sectoral approach to SECO, to obtain their feedback on these designs. In May 2011, Shandong introduced their cap-and-trade plan in Yantai City, and asked the team's advice on establishing a link with a potential sectoral approach.

During these activities, recommendations under a sectoral approach were presented to SECO for review. Also, the latest updates from California and other parts of world were introduced, for SECO to explore the feasibility to adopt international experiences on sectoral approach in Shandong.

4. Business-As-Usual, maximum technology potential scenario and crediting baseline

4.1. Statistical processes, definitions and boundaries

Data on energy consumption and cement/clinker production of the cement industry in Shandong Province is available from two sources. The first source is periodical statistics gathered and calculated by the Shandong Bureau of Statistics under the Energy Statistics Scheme. Every cement company in the province with annual revenue exceeding 5 million RMB is required to report their energy consumption and production to the Bureau on a quarterly and annual basis under the Energy Statistical Reporting System (more details in Appendix 7: template of the Energy Statistical Reporting System). For the cement industry in Shandong, the annual revenue requirement of 5 million RMB results in nearly full coverage of cement production in the area. The second source of data is statistics from the cement industry association, the Shandong Energy Conservation Office (SECO), which gathers statistics only among member companies of the association. The data from the Shandong Bureau of Statistics is the only officially recognized data, and thus was used as the basis for establishing scenarios in this project. The industry association data served as a reference to cross check the validity of the official data.

According to the Resource Conservation and Environmental Protection Department of the National Development and Reform Commission (NDRC), energy consumption in cement production is defined as energy-consuming activities within the boundaries described in Figure 5 (NDRC, 2009). At the most basic level, energy consumption for cement production can be categorized into clinker production energy consumption and the others (additives and blending). As the main co-product of cement, clinker production consumes the most energy in the production process, and energy consumption for clinker production is very similar across geographic regions.

For cement, energy consumption in the process comprises of energy consumption of clinker making, and the additional energy consumption required for additive processing, finish grinding, packaging and transport, etc. Cement energy consumption varies widely depending on the ratio of clinker and additives in the composition, and the type of additives used.

While defining the energy consumption boundary, we also need to pay attention to fuel consumption for additives preparation. Generally, additives like blast furnace slag or other slags also require drying. In documented best practices, additive drying requires around 26 kgce/tonne of additive (0.75 GJ/t) of fuel (Worrell et al., 2007). Depending on the amount of additives used, fuel consumption from this activity can significantly impact total cement energy consumption.

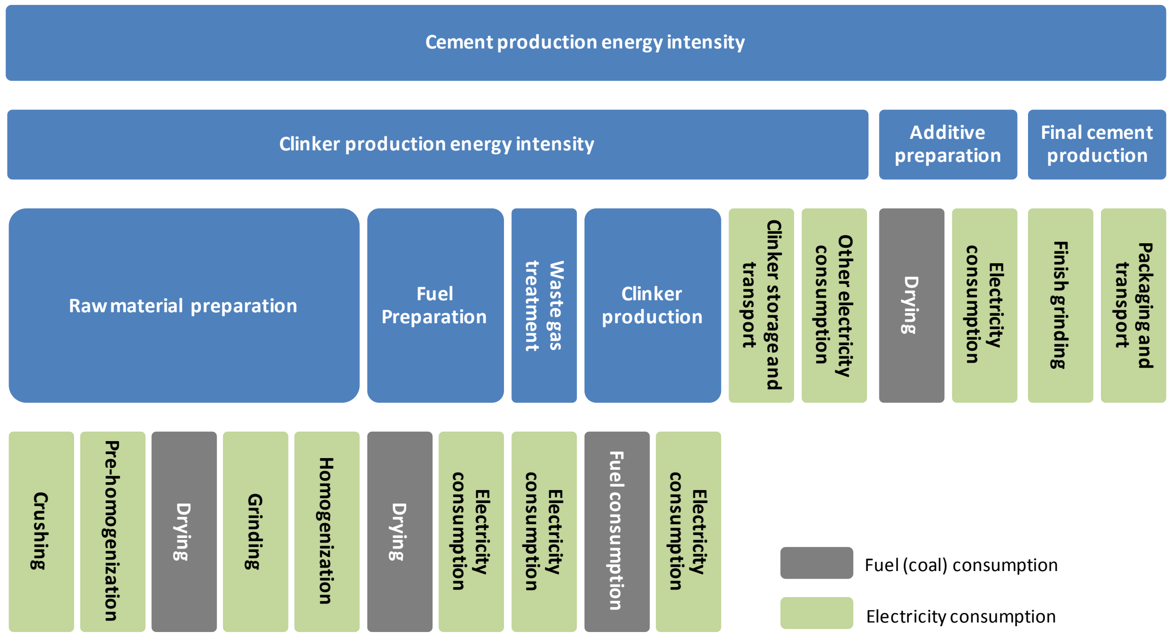

Figure 5 Cement energy consumption boundary

It should be noted that energy consumption data are not directly measured. For most cement/clinker producers, process-specific energy consumption measurement is not available. In the cement sector energy consumption data published by the Shandong Bureau of Statistics, only data on total energy consumption or energy intensity are available. There is little breakdown of energy consumption data published, for instance by finish grinding electricity consumption, additive preparation fuel consumption, etc. In order to develop modeling and scenarios for this research, certain assumptions and additional calculations were required.

Table 1 Historical data of Shandong's cement sectorprovides a summary of historical data used in this report. These data come from three different sources. Data in green are the official data published by the Shandong Bureau of Statistics (see Appendix 1). Data in blue are from SECO, without making any further calculations (see Appendix 1). Data in pink are calculated by the authors using some assumptions based on nation-wide statistics data or expert opinion (see Appendix 3). For a more detailed description of the calculation process, please refer to Appendix 2.

Table 1 Historical data of Shandong's cement sector

	单位 Unit	2006	2007	2008	2009
Total Shandong cement production	mt cem	166.0	149.1	140.0	142.7
Total Shandong clinker production	mt cl	107.0	95.9	88.0	85.1
Total Shandong clinker export	mt cl	4.8	5.9	1.8	1.1
Shandong clinker-cement ratio		0.64	0.64	0.63	0.60
Total Shandong cement production energy intensity	kgce/t cem	111.1	105.4	99.2	93.3
Total Shandong clinker production energy intensity	kgce/t cl	139.3	130.1	122.6	115.4
Coal intensity of Shandong cement production	kgce/t cem	101.1	92.9	87.5	82.0
Coal intensity of clinker production	kgce/t cl	133.1	122.4	115.2	108.0
Coal intensity of additive preparation (non-clinker)	kgce/t	43.0	39.8	40.5	43.6
Electricity intensity of Shandong cement production	kWh/t cem	81.5	101.6	95.5	92.0
Electricity intensity of clinker production	kWh/t cl	53.4	66.23	62.3	60.0
Non-clinker electricity intensity	kWh/t cem	47.23	58.9	56.4	56.2
Total Shandong cement production energy consumption	mtce	18.4	15.7	13.9	13.3
Total Shandong clinker production energy consumption	mtce	14.9	12.5	10.8	9.8
Total Shandong cement production coal consumption	mtce	16.8	13.9	12.2	11.7
among which clinker production coal consumption	mtce	14.2	11.7	10.1	9.2
among which additive preparation coal consumption (non-clinker)	mtce	2.5	2.1	2.1	2.5
Total Shandong cement production electricity consumption	10^9 kWh (TWh)	13.5	15.1	13.4	13.1
among which clinker production electricity consumption	10^9 kWh (TWh)	5.7	6.4	5.5	5.1
among which non-clinker electricity consumption	10^9 kWh (TWh)	7.8	8.8	7.9	8.0

Note: Data in green are the official data published by the Shandong Bureau of Statistics. Data in blue are from SECO, without making any further calculations. Data in pink are calculated by the authors using some assumptions based on nation-wide statistics data or expert opinion. Mt/t cem: million tonnes/tonne of cement; Mt/t cl: million tonnes/tonne of clinker Kg/mt ce: kg/million tonnes of coal equivalent

4.2. Shandong cement sector energy consumption and carbon emissions

Moreover, Shandong's cement sector, accounting for 10% of China's total cement production, is one of country's key energy-intensive sectors that have a requirement to improve energy efficiency. As the chief energy management authority in Shandong, SECO is highly interested in exploiting cooperation opportunities on capacity building, technology transfer, and finance in its cement sector under the sectoral approach.

4.2.1 Shandong energy consumption and targets

Shandong Province is one of China's largest gross domestic product (GDP) contributors and energy consumers. In 2010, Shandong's GDP reached RMB 3.9 trillion and was China's third largest economy by province that year. Shandong's industrial sector accounted for 54.3% of the total GDP, with primary and tertiary sectors[1] contributing 9.1% and 36.6% of this total, respectively. Shandong's energy consumption in the same year reached 340 million tonnes of coal equivalent (Mtce).

The energy intensity of whole economy in Shandong Province decreased progressively during the 11th Five Year Plan (11th FYP) period (2006-2010). Shandong's energy intensity (energy/GDP) reduction target was 22% during the 11th Five Year Plan (2006-2010). As one of the most energy-intensive provinces in China, Shandong was among the provinces with higher energy-efficiency targets allocated by the central government to ensure the achievement of 20% national energy intensity reduction target. This led to the implementation of various ambitious policies and measures in Shandong, particularly for the cement industry.

According to Shandong government, Shandong's energy consumption per unit gross domestic product (GDP) dropped by 22.09% over the 11th Five Year Plan period. Figure 6 shows the declining trend in energy intensity in Shandong between 2005 and 2010. During the 12th Five Year Plan (2011-2015), Shandong's energy intensity target is set at 17% reduction, which is higher than the national target of 16% (Zheng, 2011). Shandong's cement sector accounts for approximately 10% of China's domestic cement production (China Cement Association, 2010).

[1] The primary sector of the economy extracts or harvest products from the earth. The primary sector includes the production of raw material and basic foods. Activities associated with the primary sector include agriculture (both subsistence and commercial), mining, forestry, farming, grazing, hunting and gathering, fishing, and quarrying. The secondary sector of the economy manufactures finished goods. All of manufacturing, processing, and construction lies within the secondary sector. Activities associated with the secondary sector include metal working and smelting, automobile production, textile production, chemical and engineering industries, aerospace manufacturing, energy utilities, engineering, breweries and bottlers, construction, and shipbuilding.

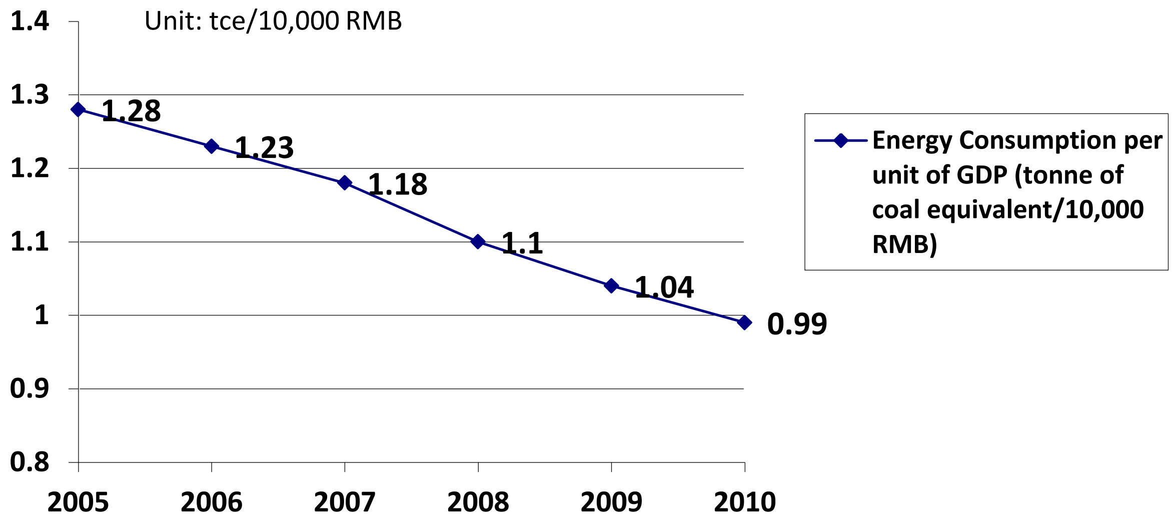

Figure 6 Shandong Energy Intensity from 2005 to 2010

Source: National Bureau of Statistics of China, 2006, 2007, 2008, 2009 and 2010. Guo Shuyu, 2011.

4.2.2 Historical Shandong cement energy intensity trends

Both overall cement energy use and energy intensity of cement production in Shandong Province declined during 2006 to 2009, the period for which data were obtained for this analysis. The most important action taken in Shandong cement sector during this period was to phase out small, inefficient vertical shaft kilns (VSKs), and to replace them with more energy-efficient new suspension pre-heater and pre-calciner (NSP) kilns. The share of NSP kilns in Shandong cement production capacity increased from 41.61% in 2005 to 80.21% by the end of 2010 (MIIT, 2011).

Based on data provided by SECO[2], the overall energy consumption of cement production in Shandong has shown a decreasing trend between 2006 and 2009 (see Figure 7). This is caused by both a decrease in cement production and the adoption of energy efficiency measures. In 2009, the energy intensity of Shandong cement production was reported to be 93.3 kgce/tonne of cement produced, approximately 16% lower than the 2006 value.

2 Data provided by SECO are compiled from the Shandong Bureau of Statistics and the local cement industry association.

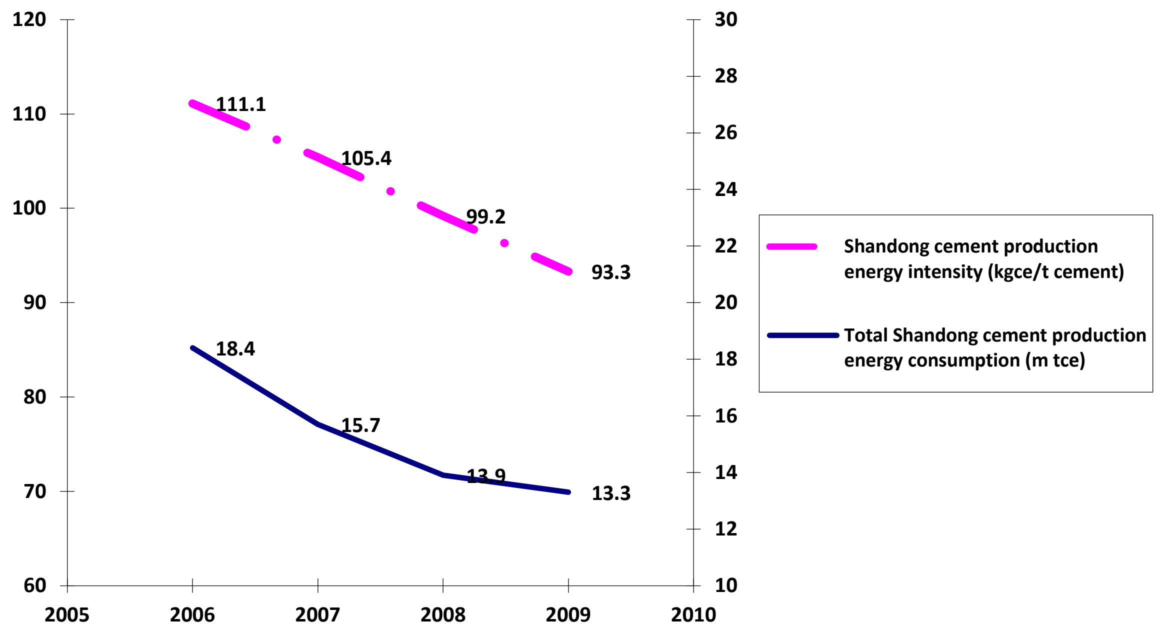

Figure 7 Total energy consumption and energy intensity of Shandong cement production 2006-2009

Source: SECO, 2010

Data for 2005 and before are not available from SECO or official statistical data published by the Shandong Bureau of Statistics. This is partially due to the fact that energy consumption and energy intensity were only measured and reported in the official statistics system during the 11th Five Year Plan, that is, from 2006 onward. Although there are data from other sources, for instance, the China Cement Association and the Institute of Technical Information for the Building Materials Industry of China, it is difficult to cross-check these data with official data for Shandong Province. Because no breakdown data is available, it is challenging to verify different measurement methodologies employed by different sources. In order to ensure the consistency of data, the research here has only presented data from 2006 to 2009.

Table 2 shows that the ratio of clinker-to-cement produced in Shandong Province was lower than the average ratio of clinker-to-cement for all of China during the 2006 to 2009 period. Since the current statistics data provided by the Shandong Bureau of Statistics do not include data on clinker imports from overseas or from other provinces, it is not possible to determine whether this lower clinker-to-cement ratio is due to the use of imported clinker or whether more additives are blended with the clinker when producing cement in Shandong Province. Energy consumption for cement produced using imported clinker will be significantly lower than energy consumption for the combined production of clinker and cement. It is unlikely that the current cement production energy consumption statistics include the embedded energy consumption in imported clinker that was used for cement production in Shandong.

Table 2 Comparison of Shandong clinker-to-cement ratio and national average values

	2006	2007	2008	2009
Shandong clinker-to-cement ratio	0.64	0.64	0.63	0.60
National average clinker-to-cement ratio	0.71	0.70	0.69	0.65

Source: SECO and China Cement Association

A study of the energy-efficiency opportunities for the Shandong cement industry was conducted by Lawrence Berkeley National Laboratory (LBNL) and the China Building Materials Academy (CBMA) in 2009 (Price et al., 2009). The study conducted an in-depth production data and energy consumption analysis for 16 cement plans in Shandong. The study showed that the average clinker-to-cement ratio in the 16 cement plans for 2008 was 0.63.

Since Shandong Province is a net importer of clinker, official statistics for Shandong are likely to significantly underestimate the actual energy intensity of cement production because the energy use for production of the imported clinker is not included in the statistics. Assuming that the actual clinker-to-cement ratio of cement production in Shandong equals the national average value for China, the energy intensity of cement production in Shandong can be recalculated as shown in Table 3.

Table 3 Comparison of Shandong cement production energy intensity using different clinker-to-cement ratios

	2006	2007	2008	2009
Energy intensity provided by SECO (kgce/t cement)	111.1	105.4	99.2	93.3
Recalculated energy intensity based on China's national average clinker-to cement-ratio (kgce/t cement)	117.1	110.6	104.1	97.5

The recalculated energy intensity value based on China's national average clinker-tocement ratio is used in this project for further discussions and analysis, rather than the official statistics provided by SECO, in order to account for the embedded energy consumption of imported clinker used in cement production in Shandong Province.

4.2.3 Shandong cement carbon intensity

CO_2 emissions of Shandong cement production are shown in Figure 8 below (recalculated value using China's national average clinker-to-cement ratio). Although an official inventory of Shandong cement sector GHG emissions is not available, CO_2 emissions of Shandong cement production can be estimated using cement and clinker energy consumption, production data and emission factors. The calculated carbon emission of Shandong cement production includes CO_2 emissions from both energy consumption and the calcination process of clinker production. For a list of emission factors used in calculation, please refer to Appendix 3.

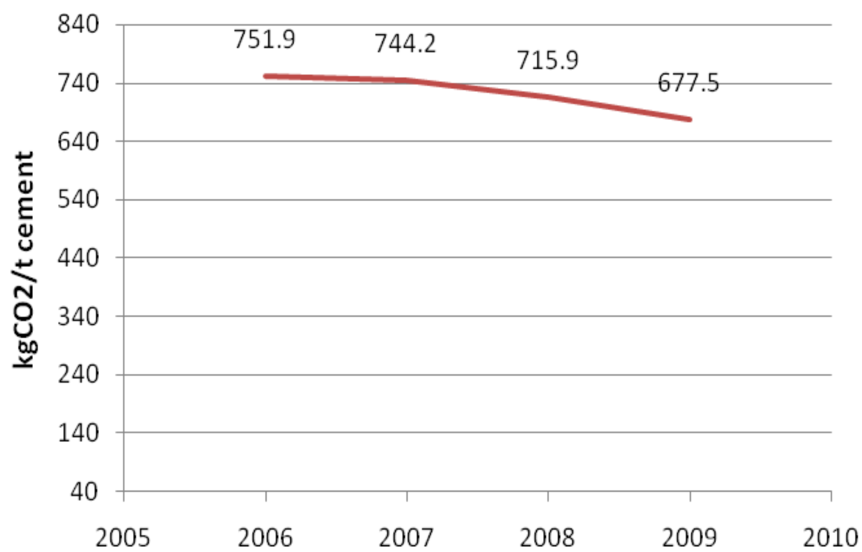

Figure 8 Shandong cement production carbon intensity

4.3. Business-As-Usual scenario

A Business-As-Usual (BAU) scenario was developed using latest official data provided by SECO based on the previous Sectoral Template in Cement Sector research that the team carried out in 2009 (Azure, 2009). There were several challenges in developing a BAU scenario including that some key data are missing. In order to appropriately model the future energy consumption and CO_2 emissions, assumptions and expert opinions were also used. There are three main elements that influence the BAU scenario, these elements are:

- **Shandong province cement output**
  According to the information provided by SECO, the Shandong government is planning to cap its annual cement production at around 140 million tonnes (Mt) during the 12th FYP. Since the province's cement production peaked in 2006, Shandong cement production has never exceeded 150 Mt in the last four years. In the updated BAU scenario, cement production is projected to have a limited growth, reaching 150 Mt of annual production by the end of 2020. However, it is worth noting that most recent statistics show an increasing trend in Shandong cement production, which was mainly caused by infrastructure building as a result of the central government's stimulus plan.

- **Phase out of Vertical Shaft Kilns**
  SECO indicated that the Shandong government is planning to completely phase out VSKs by 2015. Phasing out outdated industry capacity is a strategic action promoted by the central government to enhance the country's economic structure. The Shandong cement sector has decreased the percentage of inefficient VSKs from 66% in 2006 to 20% by the end of 2009 (SECO,

2010). It is therefore very likely that the target of complete phase-out of VSKs will be achieved by 2015, and thus full phase out of VSKs is assumed within the BAU scenario.

- **Frozen 2009 energy consumption per unit of cement or clinker production**
  Frozen energy consumption per unit of cement or clinker production from year 2009 were used in projecting the BAU scenario. While aggregated data such as cement and clinker energy intensity were obtained from Shandong Bureau of Statistics, expert opinion and calculation were used for breakdown data such as clinker electricity consumption, additive preparation fuel consumption, etc. Values of energy consumption used in the calculation can be found in Table 4.

Table 4 Process energy consumption breakdown (2009)

Energy consumption breakdown	Source	Unit	Value
VSK coal consumption	Calculated based on VSK-NSP ratio and clinker coal consumption of 2006 & 2009	kgce/t clinker	151.5
NSP kiln coal consumption		kgce/t clinker	97.1
Cement production electricity consumption	SECO	kWh/t cement	95.5
Clinker production electricity consumption	SECO	kWh/t clinker	60.0
Cement grinding and blending electricity consumption	Derived from SECO data	kWh/t cement	56.2
Additive preparation coal consumption	Derived from SECO data	kgce/t additive	43.6
Clinker-to-cement ratio	National average value	-	0.65

Based on these assumptions, the energy intensity of cement production under the BAU scenario drops from 97.5 kgce/tonne of cement in 2009 to 90.4 kgce/tonne of cement in 2020. Clinker energy intensity under this scenario decreases from 115.4 kgce/tonne of clinker in 2009 to 104.5 kgce/tonne of clinker in 2020 (see Figure 9). As the total cement production in Shandong is expected to be 140 Mt until 2020 (Zhao, 2010), the total final energy consumption of Shandong's cement production will drop from 13.8 Mtce in 2009 to 12.7 Mtce in 2020.

4.4. Defining the maximum potential scenario

One of the main activities of this project was to conduct surveys to identify current performance and actual potential of various energy efficiency and CO_2 mitigation measures for Shandong's cement sector. This information is important for establishing policy options. Beyond the BAU scenario, there are four groups of key energy saving and CO_2 mitigation measures. These are:

4.4.1 Energy-efficiency measures

Nine key measures were identified from the result of LBNL's analysis of energy-efficiency opportunities for the Shandong cement industry (Price et al., 2009). Appendix 6 lists technologies that can be adopted in Shandong and their typical emission reduction potentials.

A survey on the adoption rate of the measures was conducted with the support of SECO. The survey covered 14 cement companies representing 47% of Shandong cement production capacity.

Table 5 Adoption rate of energy efficiency measures in Shandong

Measures	Adoption rate based on survey	Adoption rate of total Shandong cement production in 2009
Replacing a ball mill with vertical roller mill in raw materials grinding	54%	43.2%
Kiln shell heat loss reduction (improved refractories)	69.2%	55.4%
Low temperature waste heat recovery power generation	243 MW	388.8 MW
Energy management and process control systems in clinker making	81.7%	65.4%
High pressure roller press as pre-grinding to ball mill in finish grinding	59.7%	47.8%
High-efficiency classifiers for finish grinding	82.9%	66.3%
Replace ball mill with vertical roller mill in finish grinding	5.4%	4.3%
Adjustable speed drives	86.1%	68.9%
High efficiency motors	82.3%	65.9%

By the end of 2009 NSP kilns accounted nearly 80% of total Shandong cement production capacity. As VSKs were not covered in the questionnaire, the adoption rate obtained from the survey applies only to NSP kiln production capacity. Therefore, the current adoption rate of total Shandong cement production in 2009 equals 80% multiplied by the survey adoption rate. In Table 5, the last column is calculated as 80% of the middle column (results from survey). For low temperature Waste Heat Recovery (WHR), the current adoption rate is estimated at 388.8 MW.[3]

Table 5 displays the results of the survey.

4.4.2 Clinker-to-cement ratio

Clinker making is the major energy-consuming process in cement production. Reducing the clinker-to-cement ratio by intergriding more additives can significantly reduce cement production energy intensity. However, the clinker-to-cement ratio in practice depends largely on building material standards and commonly accepted practices. Best practice values for additive use are based on the following European ENV 197-2 standards: for composite Portland cements (CEM II), up to 35% can be fly ash and 65% clinker; for blast furnace slag cements (CEM III/A), up to 65% can be blast furnace slag and 35% clinker (Worrell

[3] The survey covers 50% of Shandong's total cement production capacity. The adoption of WHR is absolute installed capacity. To have it reflect the whole cement industry in Shandong, the survey result has to be divided by 50%. Furthermore, as the survey only covers NSP kilns (which accounts for 80% of Shandong's capacity), it has to be multiplied by 80%.

et al., 2007). The reported clinker-to-cement ratio of the Shandong cement sector in 2009 is 0.60, while the national average for the same year is 0.65. For the maximum potential scenario, the clinker-to-cement ratio is projected to reach 0.58 (Azure, 2009).

4.4.3 Alternative raw material

Carbide slag is the most popular and encouraged alternative raw material for clinker in China (NDRC, 2008). Due to its chemical nature, carbide slag does not emit CO_2 when used in clinker production. However, the availability of carbide slag is very limited. Total national calcium carbide production in 2006 was around 14 Mt (Bao, 2006), while Shandong province's cement and clinker production for the same year were around 140 Mt and 85 Mt, respectively. In the maximum potential scenario, we assume that alternative raw material could contribute to a limited 1% of total clinker production.

4.4.4 Alternative fuels

Alternative fuel is not commonly used in cement production in Shandong. By the end of 2010, use of alternative fuel in cement kilns in Shandong was limited to one pilot project.

The research team conducted a rapid assessment of capacity building needs, technology gaps and alternative fuel potential for the cement sector in Shandong, in October 2010 (Azure, 2010). The results show that out of several alternative fuel sources available in Shandong, municipal household waste and sludge are the two sources that have significant resource potential and that local stakeholders are most interested in.

A breakdown of resource availability for alternative fuels is provided in Table 6, based on research results. The amount of sewage sludge and municipal solid waste will increase in the future, as a result of increasing urbanization process and more collection systems (Shandong Environmental Protection Agency, 2010). However, considering competition from other potential use of alternative fuel that local stakeholders are interested, i.e., power generation, the report assumes the feasible substitution rate of 15% in the maximum potential scenario until 2020 (Azure, 2010). Also, agricultural residues are not taken into account due to a lack of interest by local stakeholders in this alternative fuel source as well as higher costs in collecting widely distributed agricultural waste.

Table 6 Resource potential for alternative fuel use in Shandong cement sector

	Resource availability (kt)	Energy potential (ktce)	Substitution potential
Sewage sludge	1,000	150	1%
Municipal solid waste	20,000	2,400	14%
Agricultural residue	11,722	6,400	43%
Total		8810	55%

Source: Azure, 2010.

4.4.5 BAU and Maximum Potential Scenarios

With above maximum potential in energy efficiency and CO_2 mitigation measures applied to the Shandong cement sector, Shandong cement fossil based energy intensity can go down to 68.8 kgce/tonne of cement (see

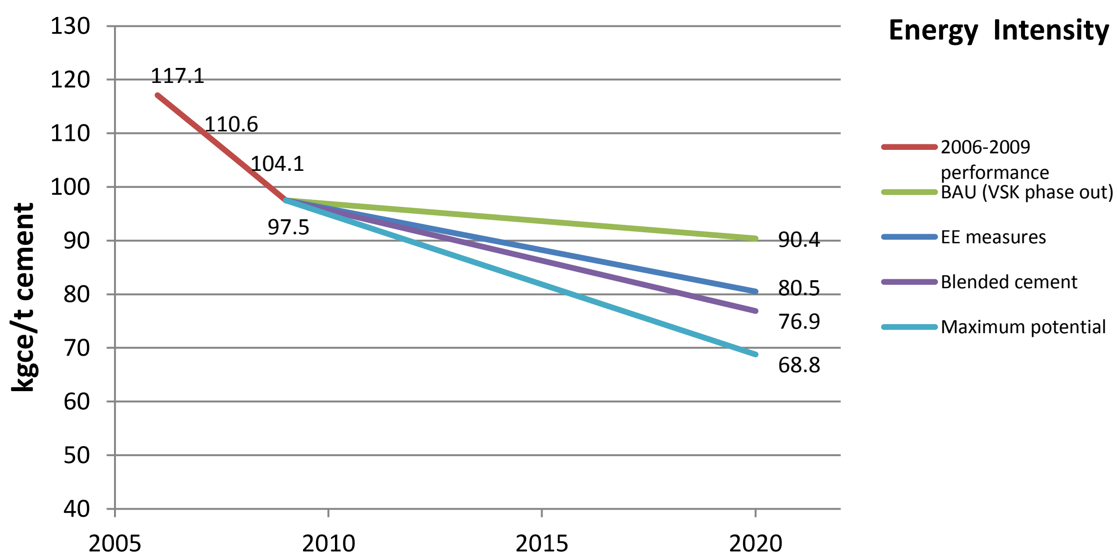

Figure 10). This value is consistent with the documented best practices value of 70 kgce/tonne (fly ash cement with clinker-to=cement ratio of 0.65) (Worrell et al., 2007). If we only consider clinker, energy intensity for maximum potential scenario goes down to 96.0 kgce/tonne.
Note that in this scenario only the potential in the year 2020 is estimated and that the values for the years in between are interpolated.

Figure 9, 10, 11 and 12 display the results of BAU and maximum potential scenario estimation till 2020.

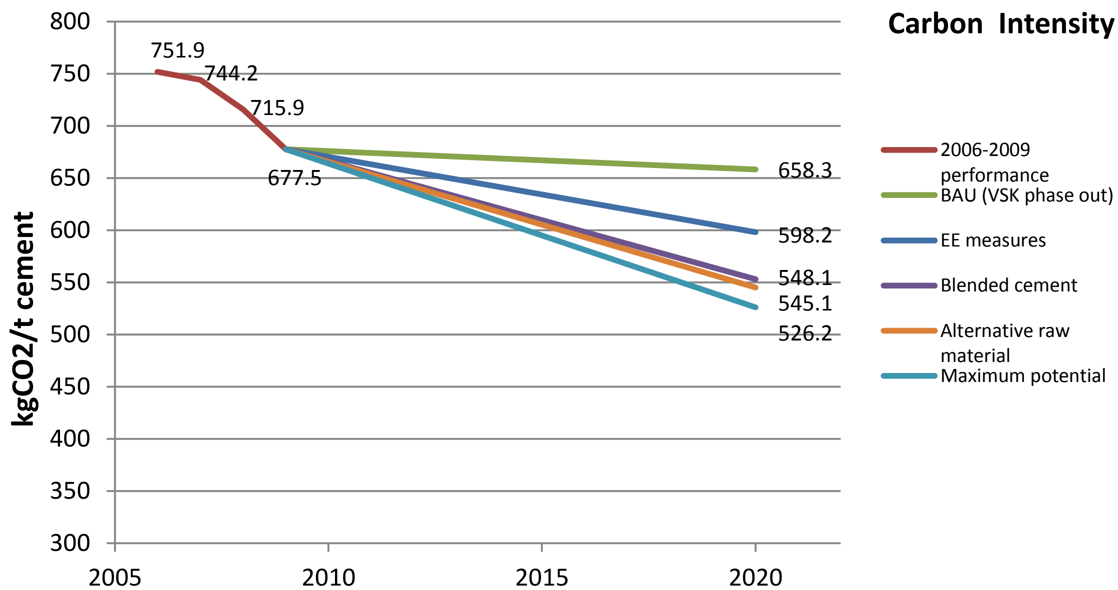

Figure 9 BAU and maximum potential scenario for Shandong cement sector (cement, carbon)

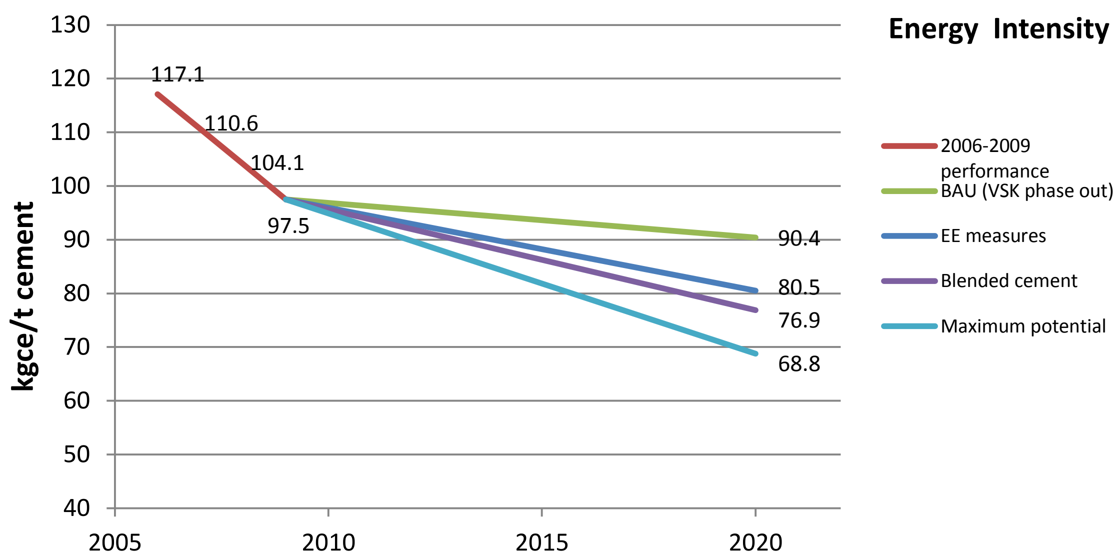

Figure 10 BAU and maximum potential scenario for Shandong cement sector (cement, energy)

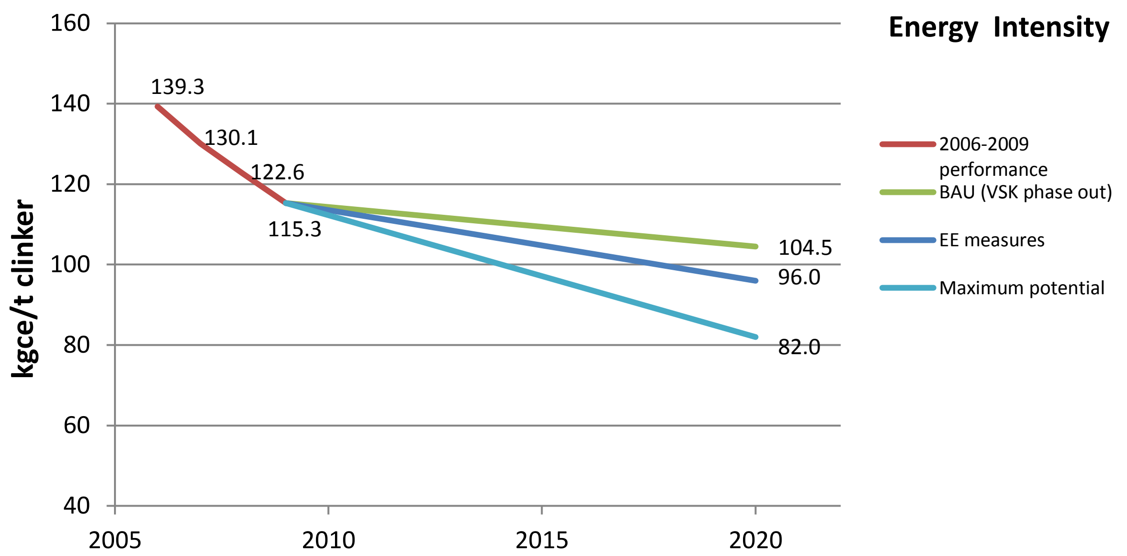

Figure 11 BAU and maximum potential scenario for Shandong cement sector (clinker, energy)

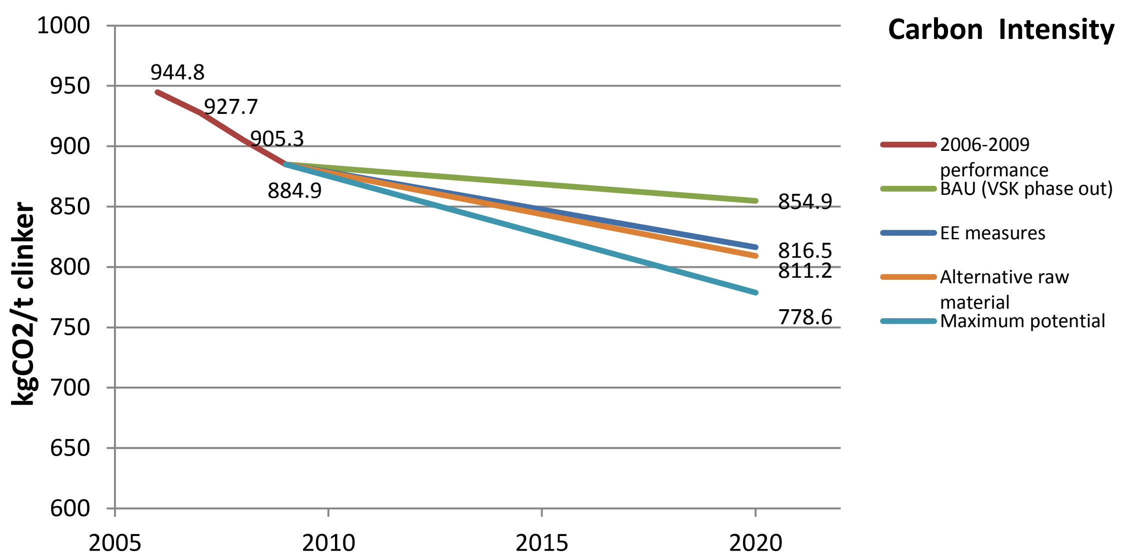

Figure 12 BAU and maximum potential scenario for Shandong cement sector (clinker, carbon)

4.5. The crediting baseline

Setting the crediting baseline is a critical issue for ensuring both the environmental integrity and the financial effectiveness of a sectoral approach project. Setting the crediting baseline close to the BAU scenario would create more credits and associated cash flow to the sector, but at the same time it raises the question of whether any of the actions taken were in addition to those that would have been taken without the project (additionality). On the other hand, setting the crediting baseline too close to the maximum potential scenario means limited credits would be generated. This could discourage cement facilities from undertaking additional efforts to increase energy efficiency and mitigate carbon emissions. The crediting baseline is a result of negotiation among the sectoral mechanism project parties. It is important, then, to not only have a BAU and a maximum potential scenario, but also to have a breakdown of feasible policy options to be implemented within the sectoral approach. Such information would provide a more concrete basis for the negotiations and further the possibility that the outcome of the negotiations would translate into successful implementation.

There are two points worth noting, especially in the discussion regarding any possible climate financing mechanism for Shandong's cement sector. The recently announced targets for China's national energy and carbon intensity goals for the 12^{th} FYP are 16% and 17% reductions, respectively. There is still uncertainty regarding the cement sector's target, except for the target related to completely phasing out VSKs. However, assuming the energy and carbon intensity reduction values are applicable for Shandong's cement sector, energy and carbon intensity would need to reach 81.9 kgce/t of cement and 562.3 $kgCO_2$/t of cement by the end of 2015. These values are significantly lower than the BAU scenario because technical trends are primarily taken into account while estimating the BAU scenario, and policies are not incorporated as there is still uncertainty about the cement sector's target and specific policies except for phasing out VSKs. In defining a final crediting baseline under a sectoral approach, the BAU scenario would need to be updated to take into account current and known future policy situation at that time of defining the crediting baseline.

Based on the current BAU scenario, the technical potential for GHG emission reductions and the likely energy and carbon reduction targets for Shandong's cement sector, this research suggests that the sector crediting baseline could be set to achieve an end point in the range of 526.2 and 598.2 $kgCO_2$/t of cement by 2020. The exact end point will need to be negotiated.

In accordance with China's energy and carbon targets the scenarios in this chapter have been defined in terms of energy intensity. However, it is worth noting that due to the specific controls on the quantity of overall cement production in Shandong that effectively stabilize or slightly reduce cement production and the energy intensity reduction targets that are likely to be in effect for the cement sector during the 12^{th} Five Year Plan period, absolute emissions from the Shandong cement sector will decrease. This is significant for potential international emission trading partners, as it means that a sectoral crediting baseline can be defined that is in accordance with Chinese policy goals and incentivizes absolute emissions reductions in Shandong's cement sector.

5. Options for credit issuing and target allocation

Options for credit issuing and target allocation are important elements in a sectoral approach package. These are the foundation of the implementation framework. This section provides some options that the Shandong government can take into account while setting up the sectoral approach package.

5.1. Credit issuing

Credits are tradable certificates of carbon or energy reduction. There is monetary value attached to credits as companies are sell them. They are based on sectoral carbon emission reductions beyond the crediting baseline, in this case, from the cement sector in Shandong province.

5.1.1 Who is issuing the credits

An agency must be designated to issue credits. It could be a provincial energy conservation office, an internationally-recognized agency, or any other competent credible authority recognized by both Shandong and foreign governments. The credit issuing agency must be independent from interests generated from credit trading.

For Shandong, the credit issuing agency could be the Shandong Energy Conservation Office (SECO), the energy managing authority in Shandong. Its experience in energy and target management can be easily developed into credit issuing capacity. However, if SECO is also designated as the authority to receive credits, there would be a conflict of interest.

Shandong can also establish a new authority, reporting to SECO, to issue credits. SECO can transfer its energy management experience to this new authority and help build its capacity. The new authority can operate separately to avoid a large increase in SECO’s workload.

5.1.2 Who is receiving the credits

There are two options related to who receives credits generated from the sectoral approach project:

Option 1 Credit issued to the government

Under this option, the credit-issuing agency provides the credits to the Shandong government. After receiving the credits, the government would then establishincentives for cement companies operating below the baseline. As the companies are not receiving credits directly, Shandong government needs to establish other incentives to encourage emission reduction from cement companies. The form of the incentives, for example subsidies or tax incentives, can be flexible and decided by the Shandong government. This option creates revenue for the Shandong government to encourage and manage energy and carbon reduction efforts in its cement sector. However, it requires considerable coordination regarding distribution from the government side. Also in this case, companies need to clearly

understand their reward regarding investment in reduction efforts. The government agency that receives the credits should be separate from the agency that issues the credits.
It should be noted that there would be a conflict of interest if SECO is both the designated authority issuing and receiving credits.

Option 2 Credits issued to individual companies
A second option is to issue credits directly to companies based on their carbon emission reductions beyond the crediting baseline. In this case, the sector baseline applies directly to individual installations or the sector baseline is allocated to individual installations based on a target allocation mechanism (see section 5.2). This is somewhat similar to emission trading by companies under a cap and trade system. However, in this case no penalty applies if the company does not meet its crediting baseline. This option provides a straightforward incentive to companies directly linked to their investment in reduction efforts and it avoids the challenging distribution issues in option 1.

However, there is uncertainty regarding the performance of Shandong's cement sector as a whole. While individual companies or installations may achieve reductions beyond the crediting baseline, the sector as a whole might still emit more carbon than the baseline allows. For example, the figure below assumes there are two cement companies, A and B, in Shandong's cement sector. A's total emissions are X tonnes of CO_2 above the baseline. B's total emissions are Y tonnes of CO_2 below the baseline. The value for Y is smaller than the value for X. The sector's total emission (A plus B's emission), is still above the baseline. Assume Company B has already received and sold credits for its emission reductions of Y tonnes of CO_2 below the baseline. Then, in order to restore the emission balance at the sector level, the Shandong government needs to ensure that emissions above the baseline by company A are covered by credits bought from the market. Thus, the government needs to buy back X tonnes of CO_2 from the market.

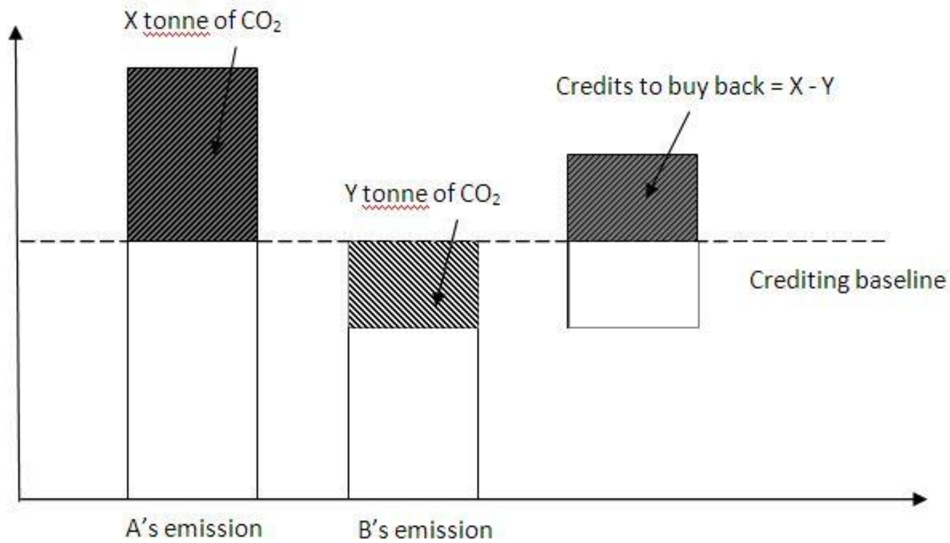

Figure 13 The case of issuing credits directly to companies

5.1.3 When are the credits issued

Option 1 Ex ante

If credits are issued to the government before the reduction occurs, finance from sales of the credits is available for the government to incentivize up-front investment in GHG emission reductions in the industry before these reductions actually take place. In addition, up-front finance provides certainty on credit price, and hence on energy efficiency pay-back.

A drawback of this option is that the buyers have uncertainty on whether the emission reduction is actually achieved. The risk of not achieving the reductions is thus shifted to the buyers.

Option 2 Ex post

There is more certainty regarding whether reductions actually happen with this option. For the buyers, there is more certainty that the credits bought represent actual emissions reduced. However, this option affects the certainty for investment in carbon reduction projects at the company or government levels due to the fact that revenue from credit generation and trading is conducted over time, leading to uncertainty on whether and when credit trading can take place, as well as other market risks that can affect the credit price.

5.2. Allocation

5.2.1 Need for target or credits allocation

Under a sectoral approach, it is not a prerequisite for the Shandong government to allocate targets to individual cement companies. When the baseline is absolute-based, and credits are issued to cement companies directly, the Shandong Government will need to allocate the sector-wide target to individual cement companies (company target). The credit-issuing agency would keep a record of company target to issue their credits. Or when there is a domestic flexibilility mechanism such as cap-and-trade combined with the sectoral approach, the government may opt for allocating tradable allowances rather than crediting individual companies against sectoral and company baselines.

The Shandong government has shown great interest in understanding allocation methodologies. Besides its role under a sectoral approach, allocation can also help Shandong better achieve its other mandated goals. For example, during the 12th Five Year Plan, the Shandong provincial government needs to dissagregate its provincial-level energy intensity target of 17% to city-level governments and possibly ultimately to individual companies. By exploring more appropriate methodologies it is believed the overall 17% target can be allocated more fairly and efficiently (see Ohshita et al., 2011 for a discussion of target allocation methodologies). Also, Shandong is going to pilot its own cap-and-trade scheme in Yantai city. Methods to allocate “allowances” to individual participants are considered as an essential part in the pilot design.

5.2.2 Options for potential target allocation

There are three major target allocation methodologies: grandfathering, benchmarking, and auctioning (Phylipsen, 2011).

With grandfathering and benchmarking, the government determines how much target or allowance each participant gets and companies get their targets or allowances for free. With auctioning, the participants buy the allowances needed: the higher price they pay, the larger allowance they get.

Grandfathering uses historical emissions as the basis of allocation. The main disadvantage of this approach is that the largest historical emitter receives the most allowances. For a large carbon emitter or energy user, the grandfathering methodology gives them windfall profits and it does not reward early action. It also does not take into account the differences in energy saving or carbon reduction potential. Hence it is not used for credits allocation, which needs to reflect companies’ different reduction actions. The **benchmarking** methodology allocates allowances on the basis of a performance measure. More efficient participants are rewarded for early action. For example, this formula can be used for allocation:

$$A = BM \times C \times CF \times AF$$

Where:

A = allowances
BM = emission benchmark (tCO_2/t product)
C = capacity
CF= historical capacity factor
AF = adjustment factor (if benchmarks are too generous)

The benchmark could be established on a value reflecting the average GHG performance of the 10% best performing installations. Finding the right benchmark is a data and labour-intensive process and it requires detailed sector and individual plant emission and energy consumption data.

The benchmarking methodology can be used for both allowance and credit allocation.

When used for allowance allocation, both the grandfathering and benchmarking methodologies give the emitter the rights to emit for free. Criticism of the grandfathering methodology is that it violates the Polluter Pays Principle. Another problem with a free allocation methodology is the amount of data and information needed. Without sufficient data and information, there will be significant uncertainty related to the results of the allocation.

Alternatively, the **auctioning** option requires companies to pay for the allowances they use. Companies in this situation need to find the right balance between their carbon reduction investment and benefits. The auctioning option applies to allowance allocation rather than credit allocation. Economically, auctioning is the most efficient mechanism for allocating allowances. Auctioning is the most costly allocation methodology to participants, and there is concern regarding the impact on competitiveness. To reduce the cost impact the revenues from the auction can be recycled in the form of subsidies for energy efficiency to the sectors under the scheme.

Credits are the most direct incentives to encourage emission reduction efforts from participating government and companies. So it is important to pay attention to how the credits should be issued. Trading partner need to consider the options carefully and make a decision early in fixing a sectoral approach package.

Although allocation methodology is not always necessary in a sectoral approach package, it still drives particular interested from Shandong government. That is because there are benefits out of practicing allocation measures. During the 12th Five Year Plan, the Shandong government is under pressure to allocate its energy and carbon intensity target to city-level and county-level governments and ultimately to individual companies. More reasonable allocation will make the energy saving and carbon reduction efforts more fair and efficient and provide better incentives to governments and companies.

6 Options and analysis on measurement, reporting and verification (MRV)

The measurement, reporting and verification (MRV) of GHG emission reduction measures and their impacts on emissions are essential for assessing the effectiveness of a sectoral approach and for ensuring the credibility and value of credits generated and traded under a sectoral approach. This chapter first reviews a number of key existing international MRV systems and then assesses the gaps in the MRV system currently in place at the provincial level in Shandong.

6.1. International GHG emission MRV systems

The project has analyzed cement sector monitoring, reporting and verification requirements from various international GHGs reporting and reduction programmes and policies. Not only do these international experiences provide useful practices that can be transferred to Shandong, but they can also be used to assess to what extent current or proposed MRV mechanisms in Shandong under a sectoral mechanism meet likely requirements on such MRV mechanisms by potential international trading partners such as California and the EU. The analysis therefore starts with a review of the MRV systems under California's AB 32 and the EU Emissions Trading Scheme (EU ETS). Subsequently, the MRV system under the Clean Development Mechanism (CDM) is reviewed as a system that is already in place in China and that can be used to build on for a potential future sectoral approach.

AB 32 in California

California Assembly Bill 32 (AB 32) was adopted in 2006 and requires California to reduce its emissions to 1990 levels by 2020. The AB 32 rule-making process has involved multiple draft regulations, input from expert committees, interactions with stakeholders, and public presentations and comment periods, and is still in process. The draft regulation involves a cap and trade program and a range of other regulatory measures.

Under the draft cap and trade regulation, regulated entities would be allowed to use offset credits to cover 4% of their total emissions. This means that total emissions in the capped sectors may be 4% above the allowed cap if all allowed offsets are used. The California Air Resources Board (CARB) distinguishes between in-state, domestic and international offsets.

REPORTING REQUIREMENTS

Mandatory annual reporting started in 2009 for emissions in year 2008 from all facilities emitting over 25,000 tonnes CO_2 per year, and electricity generators over 1 MW and producing more than 2,500 tonnes CO_2 per year, including all of California's cement factories. 2008 is considered a transition period, for which "best available" methods are used for measuring emissions. Starting for year 2009, full measurement and reporting requirements must be met. These requirements, including for cement factories, are listed in California's 2007 *Regulation for the Mandatory Reporting of Greenhouse Gas Emissions* and are further elaborated in the *Mandatory Reporting of Greenhouse Gas Emissions:*

Instructional Guidance for Operators (see URLs below[4]). Data required for cement factories are listed in the Appendix 8.

All measurement equipment and the use and maintenance of them must meet specified international or national standards.

Public availability of data submitted – Emissions data submitted to the CARB in fulfillment of these reporting requirements are public information and shall not be designated as confidential.

De minimis - The operator may elect to designate as de minimis one or more sources that collectively produce no more than 3 percent of the facility's total CO_2 equivalent emissions, not to exceed 20,000 tonnes CO_2 equivalent emissions. The operator may estimate emissions for these de minimis sources using alternative methods of the operator's choosing.

Uncertainty - An independent third party verifier will assess whether the final emissions reported by the operator is reliable within 95% of actual emissions for the entire facility.

Data checks – The operator is required to maintain systems of internal audit, quality assurance, and quality control. Routine checks should be done to identify mistakes. For example, graphs of data can be plotted over time to identify anomalies.

Data retention – All data needed to verify the emissions reported, and all data that were used for the report, must be kept for at least five years after the report is submitted. All emissions calculations must be reproducible. Procedures should be documented for the use, maintenance and calibration of any measuring equipment. Any changes to those procedures must also be recorded. This is important for determining whether changes in a facility's GHG emissions from year to year are real or due to changes in reporting quantification methods.

VERIFICATION

Verification follows a three-year cycle. Some operations need a verification report to be submitted annually and others every three years. Verification reports for cement factories are required every three years.

The verification process step-by-step

- The verifier must submit a self-evaluation of the potential for any conflict of interest that the body, its partners, or any subcontractors performing verification services may have with the operator for which it will perform verification services.
- Authorization for the verification is granted by the Executive Officer (CARB or the entity appointed by CARB to oversee reporting and verification).

[4] http://www.arb.ca.gov/cc/reporting/ghg-rep/ghg-rep-guid/ghg-rep-guid.htm

- Verification starts with the development of a verification plan in the first year of the triennial cycle. The verification plan includes documentation of the data sampling and data checking procedures.
- A site visit must be conducted in the first year of the verification cycle by one member of the verification team to each site for which a report will be submitted. The purpose of this visit is to ensure that the emissions sources are identified appropriately, and that the data management systems are in place.
- If annual verification reports are needed, data checks are performed by the verifier annually. If verification is required every three years, then the data checks are performed after the third year of the cycle.
- Verification results in a report containing the verification plan, data check and sampling procedures and findings.
- A lead verifier who was not involved in the verification will review this report.
- The operator may choose to submit revised emissions data reports based on the verification. The final verification opinion is based on the revised emissions reports.
- The verification report and opinion are due six months after the emissions report deadline from the third year of reporting.
- Facility operators must change verification bodies at least once every six years to avoid complacency and potential conflicts of interest.

Accrediting verifiers and monitoring their work – Verification bodies and individual verifiers can apply to the Executive Officer for accreditation. Individuals can be accredited as lead verifiers, verifiers and/or area specialists. Accreditation, in all of these categories, lasts 3 years, after which time the verified party needs to re-apply for accreditation. In order to verify a cement factory, at least one person in the verification team must be accredited as a cement plant specialist. The only documentation needed for accreditation approval is documentation of having taken and passed the necessary trainings.

CARB staff may participate in any verification to audit the performance of verifiers. CARB may also audit an emissions data report after a verification opinion has been provided.

EU Emissions Trading Scheme

The EU Emissions Trading Scheme (ETS) covers over ten thousand installations in the EU with net heat in excess of 20 MW in the energy and industrial sectors. These installations are collectively responsible for 40% of the EU's total greenhouse gas emissions. Phase I, 2005-7, was plagued by the over-allocation of allowances and fluctuating credit prices. Phase II of the EU ETS covers the Kyoto Protocol period – 2008-2012.

REPORTING AND VERIFICATION REQUIREMENTS

Emissions reports are submitted annually by each installation.
Different stringencies of measurement are needed for different categories of clinker facilities:
Category A facility – <= 50 kt fossil CO_2 emitted per year

Category B facility – 50 kt - 500 kt fossil CO_2 emitted per year
Category C facility – > 500 kt fossil CO_2 emitted per year
Less stringent reporting standards are allowed by permission by the competent authority if the required standards are infeasible.

A tier system for emissions calculation has helped manage the transaction costs at a reasonable level. Under the system, EU ETS participant select the tier for MRV with approval from the relevant competent authority. Tier 1 has the lowest level of accuracy, and accuracy increases as the Tier number increases. Also participants are able to get detailed clear guidance on MRV from the competent authority in their countries. Electronic templates of reporting and verification reports are provided for the online submission. These process all help to facilitate MRV and hence help manage the related costs.

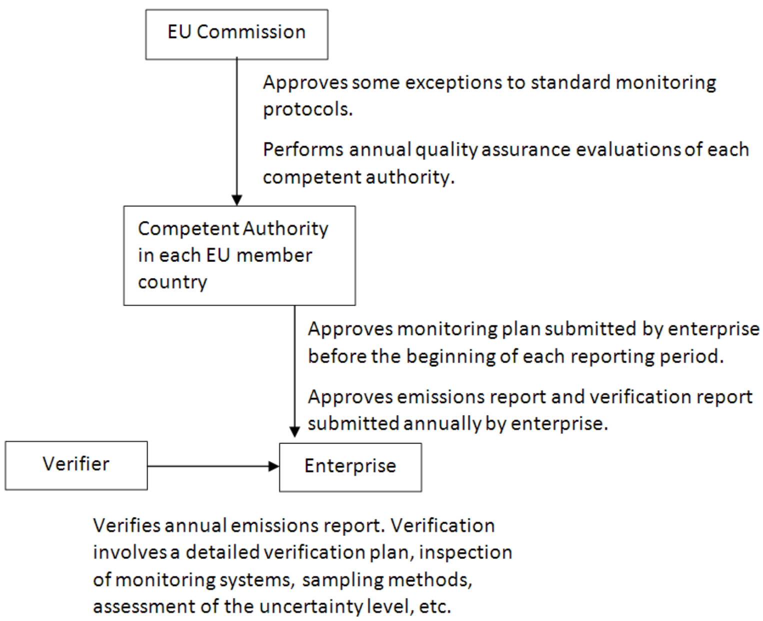

Figure 14 presents a flow diagram of the key actors and processes involved in reporting and verifying emissions under the EU ETS.

<u>Uncertainty</u> – Emissions reports include an assessment of the level of uncertainty for each input value. Certain levels of accuracy are required for each input value, depending on the size of the enterprise. The accuracy requirements for smaller enterprises are less than for larger enterprises.

<u>De minimis</u> – A group of minor source streams selected by the operator and jointly emitting 1 kt of fossil CO2 or less per year, or that contribute less than 2 % of total annual emissions of fossil CO2 can be estimated using the least rigorous reporting standards.

Public availability of data – Emissions reports are made publicly available. The enterprise may specify information that is commercially sensitive.

Accrediting verifiers and monitoring their work – Annually the EU Commission performs quality assurance evaluations of each EU country's competent authority.

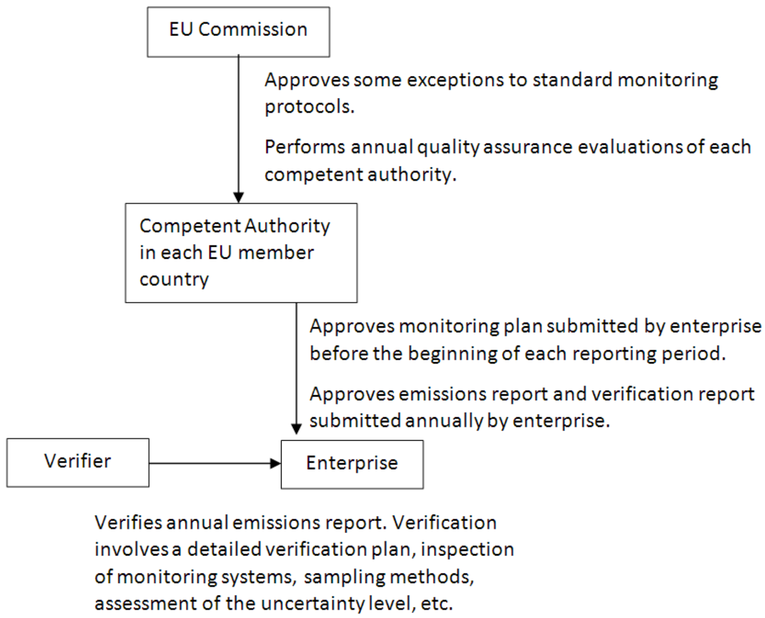

Figure 14 Flow chart of key actors and processes involved in reporting and verification

Cement Sustainability Initiative (CSI)

The Cement Sustainability Initiative (CSI) is a volunteer greenhouse gas reporting program initiated by the World Business Council for Sustainable Development and the World Resources Institute. There are currently 23 cement enterprises participating in CSI worldwide, representing about one third of global cement production.

There are currently 5 Chinese cement companies in the CSI – CRC, Yatai Group, CNBM, Sinoma, and Tianrui. They have already started reporting.

All participating companies have signed the CSI Charter.[5] This charter requires participating enterprises to:

- Report GHG emissions annually
- Provide recommendations to companies on measures to minimize typical major sources of uncertainty[6]

[5] The CSI Charter signed by all participating cement factories: http://www.wbcsdcement.org/index.php?option=com_content&task=view&id=38&Itemid=93

[6] See Table 7, http://www.wbcsdcement.org/pdf/tf1_co2%20protocol%20v3.pdf

- Have data audited by an independent third-party assurance practitioner at least once every three years
- It is up to the third-party assurance provider that whether on-site visits are needed
- Make CSI key performance indicators publicly available
- Develop a climate change mitigation strategy and publish targets and progress
- Apply CSI guidelines on health and safety, environmental and social impact assessment, rehabilitation, and fuel and raw material use

Clean Development Mechanism

The Kyoto Protocol's Clean Development Mechanism (CDM) is administered under the UN Framework Convention on Climate Change, with a secretariat overseeing the program in Bonn, Germany. The CDM was created to allow industrialized countries, with GHG emissions caps under the Kyoto Protocol, to partially meet their emissions reduction requirements by reducing emissions in developing countries, which do not have Kyoto Protocol caps.

The emissions reduced by each CDM project are estimated based on a CDM "methodology." The following approved methodologies apply to the cement sector:

- AM24 - Methodology for greenhouse gas reductions through waste heat recovery and utilization for power generation at cement plants
- ACM03 - Consolidated Methodology for emissions reduction through partial substitution of fossil fuels with alternative fuels or less carbon intensive fuels in cement manufacture
- ACM05 - Consolidated Methodology for Increasing the Blend in Cement Production
- ACM15 - Consolidated baseline and monitoring methodology for project activities using alternative raw materials that do not contain carbonates for clinker production in cement kilns
- Several waste heat recovery methodologies

As of July 2011, there were 49 cement projects registered under the CDM in China, and more Chinese cement projects in the process of applying for CDM registration. Most of these were waste heat recovery projects.

REPORTING AND VERIFICATION PROTOCOL

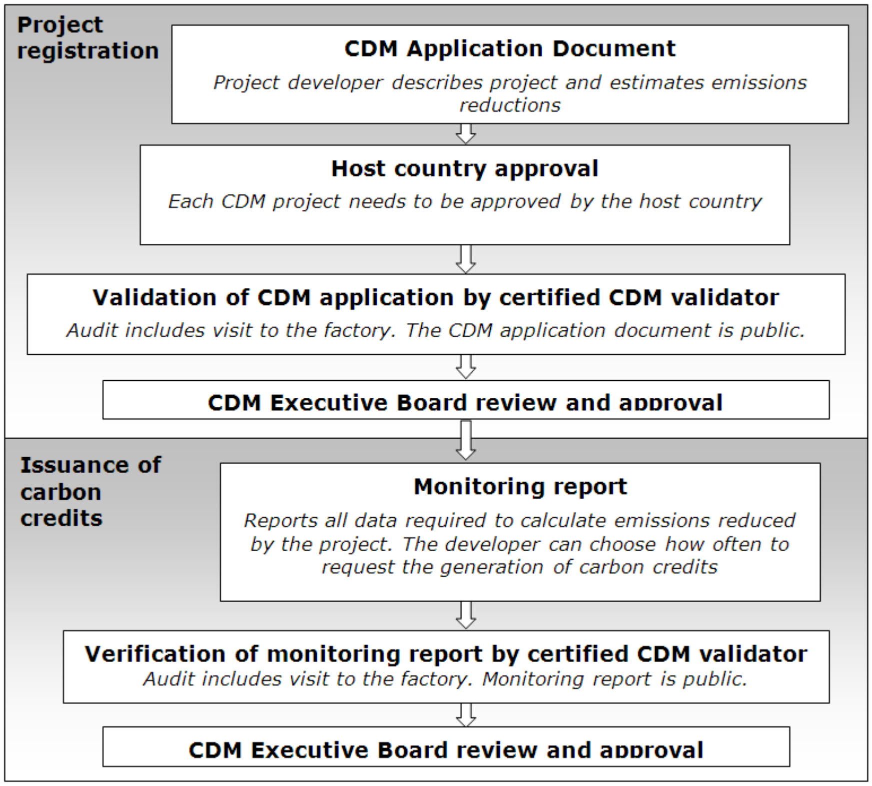

Figure 15 describes the process by which projects are registered under the CDM, and the process by which credits are issued under the CDM. Both the project registration and credit issuance processes involve the compilation of emissions data by the project developer or hired consultant into a report, the verification of that report by a third party verifier that is accredited by the CDM, and the submission of the emissions and verification reports to the CDM Executive Board for their review.

<u>Accrediting verifiers and monitoring their work</u>

There are a small number of large international verification companies that together verify most of the CDM projects worldwide. In addition, smaller local verifiers have been accredited by the CDM. Each project applying for CDM registration is reviewed and approved by the CDM Executive Board. This review typically involves a review of the project documents by someone at the CDM secretariat or a hired consultant. In addition to this oversight, verification companies can undergo spot checks on the quality of their work. These spot checks have resulted in the suspension of two large international verification companies over the last three years for failure to comply with the CDM verification requirements.

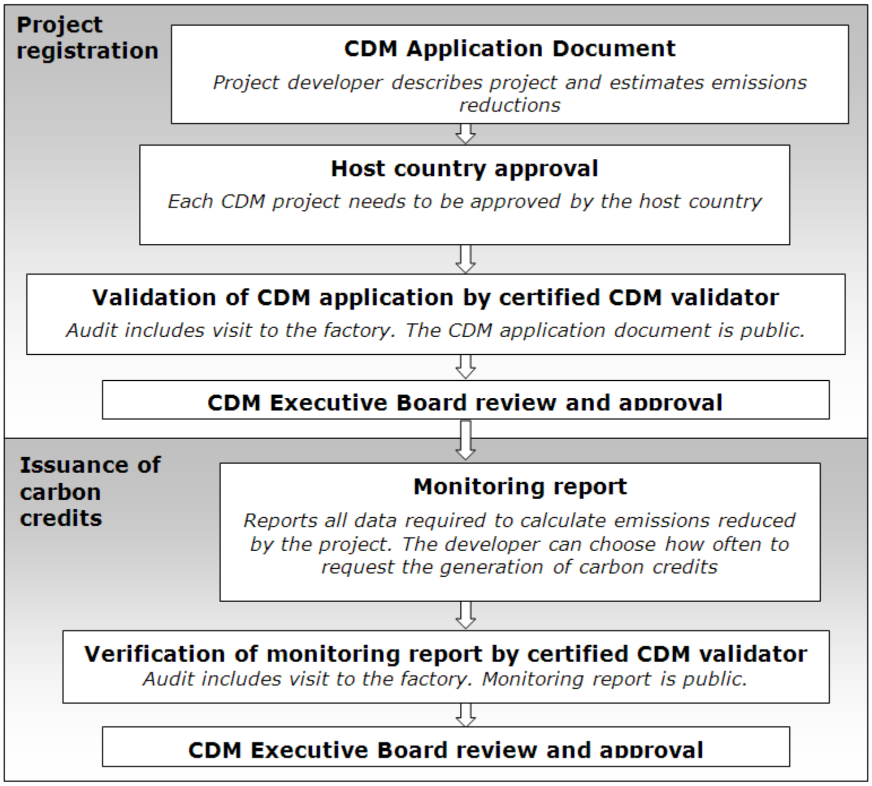

Figure 15 Flow chart of key actors and processes involved in reporting and verification

MRV designs under the sectoral approach

While designing the MRV component of a sectoral approach project for Shandong's cement sector, the report focused on the following principles:

- make the best use of existing practices;
- balance accuracy and compliance costs;
- further increase MRV capacity beyond the sectoral approach.

6.2. MRV under a sectoral approach

Credits, generated and traded under the sectoral approach, are given for the "reductions" made, which are defined as the difference between actual emissions and crediting baseline. Therefore, both the crediting baseline and actual emissions requirement need to be measured, reported, and verified.
The MRV requirements for the crediting baseline have to be negotiated and agreed upon by Shandong government and international partners. The research suggests that data and factors in defining the crediting baseline should be included. Since the crediting baseline is negotiated based on the BAU scenario and maximum reduction potential, MRV of the crediting baseline can be on the inputs for the BAU and maximum reduction scenarios. Therefore, Table 7 lists the data and factors that require MRV for the crediting baseline, under this research.

Table 7 Verification requirements for the BAU and maximum reduction scenarios

	BAU scenario and Maximum carbon reduction potential
Growth rate in cement and clinker production	To verify both Shandong's aggregate and company-level production data and calculation methodology
VSK and NSP use	To verify both Shandong's aggregate and company-level production data and calculation methodology
Energy efficiency technologies employed in total production capacity	To verify company level data and calculation methodology
Alternative fuel use	To verify company level data and calculation methodology
Alternative raw materials use	To verify company level data and calculation methodology
Fuel emissions factor for coal, electricity and alternative fuels	To verify company level, regional level, sub-grid level or national level data, depending on certainty requirement
Clinker-to-cement ratio	To verify aggregate and company-level data
Carbon reduction potential of energy-efficiency technologies	To verify company-level data and calculation methodology
Process emission factor of raw materials	To verify company level or regional level data, depending on certainty requirements

MRV of actual emissions can be either on carbon emissions directly, or calculated emissions from energy consumption and process activities. Such calculations are commonly applied, for example in the EU ETS. The latter method, due to higher accuracy and lower costs, is preferred under the sectoral approach. Factors for MRV under the calculation method include: energy activities, energy and raw material consumption and conversion factors. For the cement sector, the calculation needs to cover emissions from both energy (fuel and electricity) use and from processes (raw material processing). MRV applies to both the data and the calculation process (how the enterprise calculated its total emission based on data and conversation factors).

In China, currently there are several schemes for energy monitoring and reporting, including Energy Statistical Reporting, Top-1000 Enterprise Scheme and the Key Energy-Using Enterprises. These monitoring and reporting systems are described in detail in Appendix 7. Any MRV system for a sectoral approach would likely have to be based upon these programmes. However, in order to match typical international requirements on credibility, transparency and accuracy a number of modifications and additions would have to be made.

Verification not only concerns the data itself, but also the process by which the data was generated. This focus on the process of generating monitoring data and performing calculations ensures that the verifier has a clear understanding of how the monitoring data came about and what might cause the changes in GHG emissions from one period to another. Both in the case of California's AB 32 and the EU ETS this means that the operators of a cement plant need to submit monitoring plans in which they explain how they will conduct monitoring of GHG emissions in accordance with the regulations set out for measuring and calculating GHG emissions by relevant regulatory bodies. Subsequently, an independent verifier assesses whether the operator has implemented its monitoring system in accordance with this approved plan. A clear benefit of this approach is that data transparency greatly improves compared to a system that does not include verification of the monitoring system at the operator level.

Verification within current statistical and policy mechanisms in China focus on the underlying energy saving achievements of companies (see Appendix 7), rather than on the processes that generate the data that demonstrate these achievements. Furthermore, verification procedures are geared towards larger enterprises and are based mostly on government capacity to conduct the verification. Such systems cannot meet the requirements of a sectoral approach to verify emission data by a large group of enterprises of varying sizes.

Under a sectoral approach it is therefore recommended to develop guidance on measurement and calculation for different sizes of operators, let operators develop and submit monitoring plans to SECO or a provincial GHG emission authority. This authority or SECO would then approve monitoring plans and verification of implementation monitoring plans should be conducted by independent verifiers.

All international systems recognize that there is a trade-off between data accuracy and the cost of measurement and verification, in particular for smaller installations. Therefore most systems have categorized data uncertainty and has developed appropriate measurement, calculation and verification methodologies to validate monitoring data within each respective data category. For example, the EU ETS has implemented a tier system where data in each tier is generated according to different methodologies each with its own uncertainty in the final numbers. Such systems can help balancing the cost of measurement and verification versus the accuracy of the reported data as long as the uncertainty of reported data is also made clear.

The current energy statistical system in China focuses mostly on large energy intensive enterprises. Procedures would still have to be developed to specify MRV modalities of smaller enterprises. In elaborating such MRV procedures it is important to strike an appropriate balance between cost of measurement and verification and accuracy and to be more explicit about uncertainty in monitoring data, so that this can be taken into account in the issuing of credits.

All international GHG emission MRV systems require independent third-party verification of emission monitoring reports and procedures. Currently, no such requirement is in place for submitting energy monitoring data for China's statistical system. This means that there is no data transparency at the plant level and that it is not possible to assess data accuracy, or even to put a rough uncertainty band around reported statistical data. In order for a sectoral approach to generate credible emission reduction credits its MRV system should include independent third-party verification on monitoring data and procedures.

All international GHG emission MRV systems reviewed in this research mandate that the monitoring reports are accessible to the general public. This enhances data transparency and thereby strengthens the credibility of these systems. However, making plant level monitoring reports publicly available is not strictly necessary in order to implement a credible sector no-lose crediting mechanism. A solid framework for independent third-party verification of monitoring plans, implementation and reports can achieve the same.

In China aggregate statistical data per sector is published, industry associations and statistical bureaus have detailed datasets, but these are not public. As indicated above, it is not strictly required to change this. However, in addition to the above recommendations to incorporate independent third-party verification in the sectoral approach MRV system it is recommended that the guidelines and regulations that govern measurement, reporting and verification of GHG emission data are periodically reviewed by the trading partner in the sectoral mechanism in order to bolster confidence in the MRV system.

An accreditation system needs to be established in order to certify eligible independent verifiers. Such a system normally also requires and independent accreditation body in order to determine the eligibility of each verifier in accordance with the rules of the MRV system. While for domestic GHG emissions reduction schemes such accreditation bodies can be set by the national or local governments themselves, as is the case within the EU and California, for international schemes accreditation needs to be governed by an independent accreditation body. As sectoral crediting mechanisms are likely to first emerge as bilateral trading schemes it is up to the trading partners to define whether the accreditation body could be a national government body in the country or province that generates the credits, or whether it should be a separate jointly defined independent body. While the latter is probably preferable from the perspective of replicating and scaling up sectoral mechanisms to a broader geographical coverage, the first approach is likely to be more feasible in the near term within China's MRV context.

6.3. Institutional framework

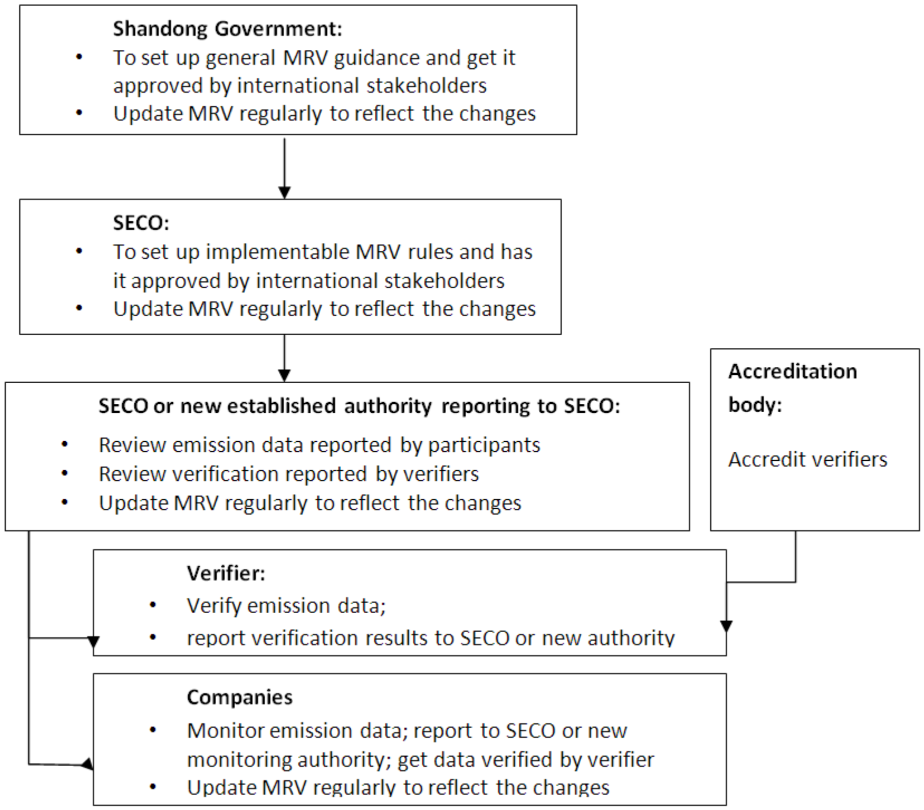

Figure 16 provides a suggested institutional framework for government authorities, participants and verifiers' roles and responsibilities under a sectoral approach for the cement sector in Shandong province.

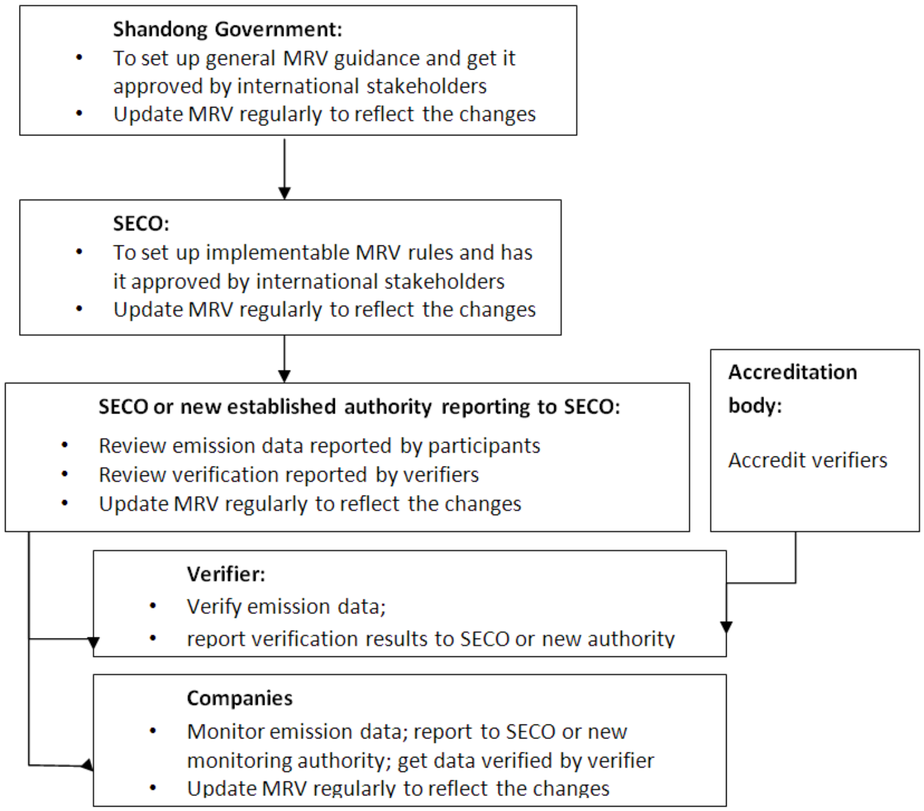

Figure 16 Institutional framework under sectoral approach

As the main party in a bilateral sectoral crediting mechanism the Shandong provincial government proposes general roles and responsibilities for the MRV system, as well as the principles for implementing the system. This proposal would then be subject to approval by the international trading partner.

A local provincial government body should then be appointed by the Shandong provincial government in order to develop detailed implementing guidelines and regulations for the MRV system. In the case of Shandong SECO would be an obvious choice as the institution to be charged with this responsibility.

SECO in turn would then define a provincial GHG emission authority to oversee the implementation of the MRV regulations and to manage the monitoring data and reports. SECO could choose to take on the role of provincial GHG emission authority itself or it could create a new office for this purpose. SECO has extensive experience reviewing energy consumption data reported by enterprises and checking its completion against targets during 11th Five Year Plan. SECO would therefore be a logical choice as the provincial GHG emission authority. However, SECO already has considerable responsibility under its existing mandate to manage energy conservation in Shandong, resulting in a significant workload. From this point of view creating a separate entity with a focused mandate on GHG emissions MRV might be more desirable.

7 Conclusions

A sectoral approach can be defined as an "organized action by key product producers in a specific industry sector and their host governments to address the greenhouse gas emissions from their products and processes,…" (WBCSD, 2009) and is aimed at broadening government and national ownership over public sector policy and increasing coherence between policy, spending and results (European Commission, 2007).

This research explored options for developing a sectoral approach based on the concept of a sector no-lose target in the cement sector in Shandong. While the policy dynamics during the research did not allow for definite conclusions on the desirability and feasibility of specific design options, the research nevertheless contributed to creating a better understanding of the decisions that need to be made and the issues that need to be resolved to establish a sectoral approach. Furthermore, it was able to scope out the options that exist for solving these issues and making these decisions.

This research has made significant progress in the process of data gathering as a basis for developing sectoral GHG emission scenarios for the cement sector at the provincial level in China. It also has shown how different datasets could be combined to generate an improved basis for developing cement sector GHG emission scenarios. A survey-based approach to estimating GHG emission reduction potential resulted in a good response rate covering over half of Shandong's cement production capacity. This progress on improving data gathering process and results provide a more credible and robust basis for defining a potential future sector no-lose target for the cement sector in Shandong.

Despite the progress this research has made in some areas of data gathering, concerns remain regarding the transparency of the data sets underlying the data that was used for this research. A MRV system should explicitly address this problem in a verifiable manner. Government needs to set up a data reporting system which not only request data but also regulates and provides guidance on calculation methodologies to companies that are required to report GHG emission data, so that the transparency, reliability, accuracy and credibility of aggregate statistical data is improved. This would improve the buildup of solid historical data, which would provide a stronger basis for developing future GHG emission scenarios and establishing the sector crediting baseline.

Scenario analysis shows that there is large remaining potential for GHG emission reductions relative to BAU in Shandong's cement sector. The major part of this potential is made up of energy efficiency measures. However, for the cement sector to move beyond China's economy wide GHG emission intensity targets under the 12th Five Year Plan and to achieve GHG emission reduction targets in the cement sector that are consistent with China's 2020 economy wide GHG emission intensity target or -40 to -45%, more use of alternative fuels and raw materials needs to be encouraged.

While this research is not intended to provide a specific recommendation on defining the sector crediting baseline a range within which the sector crediting baseline can be set has been derived. It is recommended that a sector crediting baseline is set to achieve between 526.2 and 598.2 kgCO2/t cement by 2020. It should be noted that, taking into account Shandong's policies to restrict overall cement production during the 12th Five Year Plan, this will result in an absolute, as well as intensity-based reduction of GHG emissions.

Over the course of this research the National Development and Reform Commission (NDRC) started to encourage provinces and cities to experiment with flexible mechanisms such as emissions or energy savings trading under a cap. While such mechanisms are in principle compatible with a sectoral approach and a sector no-lose target, this policy signal from the NDRC did focus the policy attention more strongly on the design of cap-and-trade systems. This has meant that less progress could be made with government counterparts in exploring specific design options for a sectoral approach. However, at the same time these government counterparts used this research to inform their thinking and their own research into policy design options for pilot cap-and-trade systems. The most concrete example of this is the use of the research results by SECO in developing its energy saving cap-and-trade pilot program in Yantai. Under this program, Yantai city-level government will be issuing credits and county-level governments would be the trading partners receiving credits.

A critical component underpinning the credibility of a sectoral approach is its MRV system. Based on a comparison with international MRV systems it is recommended that in order to establish a sector crediting mechanism Shandong government would implement a robust third-party independent verification system to verify both the process and results of emission measurements, calculations and reports by plant operators. In parallel, work could start to build the capacity of cement companies to conduct detailed monitoring and reporting of GHG emission data and develop standardized methodologies and guidelines for this reporting. Transfer of international experience in this area could be further encouraged, as well as participation of cement companies in voluntary initiatives such as the Cement Sustainability Initiative.

SECO has been the main government counterpart in this research. Many of the institutional functions that need to be established to implement a sectoral mechanism could be performed by SECO and in first instance this was often suggested during meetings with SECO. However, in the eventual design of a sectoral mechanism care has to be taken not to create conflicts of interest within SECO, e.g. regulating MRV and receiving credits. Several design options have been presented in this report to prevent this problem. Final design choices on these institutional arrangements, however, largely depend on design choices regarding the issuance and ownership of emission credits under a sectoral approach. With this in mind and considering the existing institutional workload of SECO, it is likely that new agencies would have to be established to take on specialized roles in the sectoral mechanism.

This research has made further steps towards understanding the feasibility of implementing a sectoral approach in the cement sector in Shandong. On the whole it can be concluded that such a sectoral approach could be implemented in Shandong's cement sector. However, further work would be needed to elaborate the specific crediting arrangements, MRV and institutional mechanisms, as well as defining the crediting baseline under such a sectoral approach. This should preferably be done in conjunction with an international partner in the sectoral crediting mechanism. This research has laid out the options to inform such a discussion with an international trading partner towards establishing an actual sectoral approach based on the sector no-lose concept in the cement sector in Shandong.

There are political challenges that need to be overcome before a sectoral approach can be really implemented. First, a committed potential emission credit trading partner needs to be identified. Detailed negotiation is consequently necessary to scope out the detailed arrangements of the design of the sectoral package and crediting mechanism. Second, a clear signal from the central government in China to encourage further development of sectoral approaches is necessary in order for provincial governments such as Shandong to have sufficient mandate to further develop international collaboration on sectoral approaches with potential emission trading partners. In the current context of international climate negotiations such a policy signal from the Chinese central government remains absent.

However, lack of progress in the international climate negotiations should not prohibit progress on practical steps towards improving the market readiness for sectoral approaches, particularly since such market readiness supports stated Chines policy goals to implement domestic emissions trading systems or energy saving trading systems. As a start, taking Shandong as an example, the MRV framework could be further improved and capacity building on MRV can be conducted to prepare cement companies for a potential sectoral approach or emissions trading scheme. As Shandong is going to pilot a cap-and-trade system in Yantai city by the end of 2011, the project team will continue to provide advice on the design of the system, including target setting, allowance allocation and MRV. Through the implementation of this cap-and-trade system, it is believed both Shandong government and participating companies' capacity will be significantly improved.

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Appendix 1: Official Shandong Cement Energy Statistics

	单位|Unit	2006	2007	2008	2009
水泥产量|Total cement production	万吨 (10 kt)	16600.00	14908.47	13997.56	14271.41
熟料产量|Total clinker production	万吨 (10 kt)	10700.00	9588.33	8800.37	8512.58
熟料出口或向外省出售的量| clinker exported abroad or to other provinces in China (-)	万吨 (10 kt)	484.50	590.48	177.47	107.63
熟料进口和从外省调来的量| Clinker imports (from abroad or other provinces in China) (+)	万吨 (10 kt)	n/a	0.00	0.00	0.00
窑炉总数|Total number of kilns	个 (#)	0.00	884.00	754.00	510
立窑总数|VSK kilns	个 (#)	n/a	836	696	445
新型干法|Rotary kiln-NSP	个 (#)	n/a	48	58	65
湿法回转窑|Rotary kiln-Wet	个 (#)	n/a	n/a	n/a	n/a
水泥生产综合能耗|Total fuel intensity of cement production	千克标煤/吨 (kgce/t)	111.09	105.42	99.20	93.32
水泥煤耗|Fuel intensity of cement production	千克标煤/吨 (kgce/t)	n/a	92.94	87.46	82.00
水泥电耗|Electricity intensity of cement grinding/blending	千瓦时/吨 (kWh/t)	n/a	101.55	95.52	90.00
熟料生产综合能耗|Total fuel intensity of clinker production	千克标煤/吨 (kgce/t)	n/a	n/a	n/a	115.00
熟料煤耗|Fuel intensity of clinker production	千克标煤/吨 (kgce/t)	n/a	n/a	n/a	108.00
熟料电耗|Electricity intensity of clinker production	千瓦时/吨 (kWh/t)	n/a	n/a	n/a	60.00
石灰石比例|Percentage of limestone	%	n/a	n/a	n/a	70-80

Source: Shandong Statistics Bureau, provided by SECO.

Appendix 2: Historical and scenario data assumptions and calculations

		Calculation process	2006	2007	2008	2009
A	Total Shandong cement production					
B	Total Shandong clinker production					
C	Total Shandong clinker export					
D	Shandong clinker-cement ratio	D = B/A				
E	Total Shandong cement production energy intensity					
F1	Total Shandong clinker production energy intensity					
F2		F2 = N2/B				
G1	Coal intensity of Shandong cement production					
G2		G2 = O2/A				
H1	Coal intensity of clinker production					
H2		H2 = P2/B				
I1	Coal intensity of additive preparation (non-clinker)	I1 = P1/B				
I2		I2 = P2/B				
J1	Electricity intensity of Shandong cement production					
J2		J2 = R2/A				
K1	Electricity intensity of clinker production					
K2		K2 = S2/B				
L1	Non-clinker electricity intensity	L1 = T1/A				
L2		L2 = T2/A				
M	Total Shandong cement production energy consumption	M = A x E				
N1	Total Shandong clinker production energy consumption	N1 = F1 x B				
N2		N2 = H2 + K2				
O1	Total Shandong cement production coal consumption	O1 = G1 x A				
O2		O2 = coal. % value from CCA Shandong cement sector energy consumption data x E x A				
P1	among which clinker production coal consumption	P1 = H x B				
P2		P2 = D(200X)/D(2009) x H1(2009)/O1(2009) x O(200X)				
Q1	among which additive preparation coal consumption (non-clinker)	Q1 = O1 - P1				
Q2		Q2 = O2 – P2				
R1	Total Shandong cement production electricity consumption	R1 = J1 x A				
R2		R2 = elec. % value from CCA Shandong cement sector energy consumption data x E x A				
S1	among which clinker production electricity consumption	S1 = K1 x B				
S2		S2 = D(200X)/D(2009) x S1(2009)/R1(2009) x R(200X)				
T1	among which non-clinker electricity consumption	T1 = R1 - S1				
T2		T2 = R2 - S2				

Estimates calculated using assumptions
Derived from SECO data
Data provided by SECO

Appendix 3: Factors Used in Calculation

Conversion factor		Unit	
GJ to tce	0.03	tce/GJ	National Statistical Bureau, Guideline on Energy Statistics
kWh to tce	0.0001229	tce/kWh	National Statistical Bureau, Guideline on Energy Statistics
Process emission factor			
Clinker	0.53	tCO_2/t	Ecofys, 2009
Alternative raw material	0.00	tCO_2/t	
Fuel emission factor			
Coal	2.77	tCO_2/tce	IPCC, 2006
Alternative fuel	2.33	tCO_2/tce	See calculation
Overall electricity use allocation factor			
Clinker	0.55		Calculated based on SECO data 2009
Non-clinker	0.45		Calculated based on SECO data 2009
Kiln specific coal intensity			
VSK	151.48	tce/t-cl	Calculated based on VSK-NSP ratio and clinker coal consumption of 2006 & 2009 (33.77% NSP:66.23% VSK in 2006; 79.63% NSP: 20.37% VSK in 2009)
NSP	97.13	tce/t-cl	Calculated based on VSK-NSP ratio and clinker coal consumption of 2006 & 2009 (33.77% NSP:66.23% VSK in 2006; 79.63% NSP: 20.37% VSK in 2009)
coal intensity			
Additives preparation	0.04	tce/t	Calculated from SECO 2009 data
Operating hours			
WHR	6840	hr/year	CDM experience

Appendix 4: Energy Efficiency Technology Implementation Survey: Questionnaire

	Applied?	Remarks	Estimated energy saving amount (ktce/year)	Implementation barriers	Estimated investment (10000 RMB)
复合水泥（混合材：粉煤灰、火山灰和高炉矿渣） Blended cement (additives: fly ash, pozzolans, and blast furnace slag)					
低温余热发电 Low temperature waste heat recovery power generation					
在最终粉磨中用立式辊磨机取代球磨 Replace ball mill with vertical roller mill in finish grinding					
高压辊压机作为预粉磨 High pressure roller press as pre-grinding to ball mill in finish grinding					
降低窑外壳热损耗（改进耐火材料） Kiln shell heat loss reduction (improved refractories)					
熟料生产中的能源管理和工艺控制系统 Energy management and process control systems in clinker making					
在原料粉磨中用立式辊磨机取代球磨 Replacing a ball mill with vertical roller mill in raw materials grinding					
调速驱动 Adjustable speed drives					
最终粉磨中使用高效的选粉机 High-efficiency classifiers for finish grinding					
高效电机 High efficiency motors					

Appendix 5: Energy Efficiency Technology Implementation Survey: Results

Technologies	Unit	Production capacity in total/ capacity employing certain technoloy in total
原料粉磨能力 Capacity of raw materials grinding	**10,000 tonne/year**	6954
在原料粉磨中用立式辊磨机取代球磨 Replacing a ball mill with vertical roller mill in raw materials grinding	**10,000 tonne/year**	3755
熟料生产总产能 clinker production capacity	**10,000 tonne/year**	4521
降低窑外壳热损耗（改进耐火材料） Kiln shell heat loss reduction (improved refractories)	**10,000 tonne/year**	3130
低温余热发电 Low temperature waste heat recovery power generation	**kW**	243,315
熟料生产中的能源管理和工艺控制系统 Energy management and process control systems in clinker making	**10,000 tonne/year**	3694
水泥生产总产能 cement production capacity	**10,000 tonne/year**	6677
高压辊压机作为预粉磨 High pressure roller press as pre-grinding to ball mill in finish grinding	**10,000 tonne/year**	3983
最终粉磨中使用高效的选粉机 High-efficiency classifiers for finish grinding	**10,000 tonne/year**	5532
在最终粉磨中用立式辊磨机取代球磨 Replace ball mill with vertical roller mill in finish grinding	**10,000 tonne/year**	360
调速驱动 Adjustable speed drives	**10,000 tonne/year**	5747
高效电机 High efficiency motors	**10,000 tonne/year**	5497
复合水泥（混合材料：粉煤灰、火山灰和高炉矿渣） Blended cement (additives: fly ash, pozzolans, and blast furnace slag)	**10,000 tonne/year**	5942

Appendix 6: Potential Technologies to be Adopted by Cement Enterprises in Shandong Province

No. *	Technology	Typical CO2 Emission Reduction Potential **	CO2 Emission Reduction Potential in 16 surveyed plants in Shandong (kton CO2)	Notes
Commercialized energy-efficiency technologies for NSP kiln plants				
1	Blended cement (additives: fly ash, pozzolans, and blast furnace slag)	194.8 kg CO2/ton cement	378.1	Replace 20% of the clinker with additives (higher share of additives). Emission reduction is for both energy saving and reduced calcination.
2	Low temperature waste heat recovery power generation	31.7 kg CO2/ton clinker	57.6	A waste heat recovery (WHR) system can effectively utilize the low temperature waste heat of the exit gases from the suspension preheater (SP) and air quenching chamber (AQC) in cement production. The WHR captive power plant consists of WHR boilers (SP boiler and AQC boiler), steam turbine generators, controlling system, water-circulation system and dust-removal system etc. The steam from SP boiler and AQC boiler is fed to the steam turbine generator to produce power.
3	Replace ball mill with vertical roller mill in finish grinding ***	26.7 kg CO2/ton clinker	70.4	Roller mills employ a mix of compression and shearing, using 2-4 grinding rollers carried on hinged arms riding on a horizontal grinding table. Typical energy use is 18.3-20.3 kWh/t clinker compared to 30-42 kWh/t clinker for a ball mill, depending on the fineness of the cement.
4	High pressure roller press as pre-grinding to ball mill in finish grinding ***	25.1 kg CO2/ton clinker	186.3	A high pressure roller press, in which two rollers pressurize the material up to 3,500 bar, can be installed as the pre-grinding before ball mills for finish grinding, improving the grinding efficiency dramatically.
5	Kiln shell heat loss reduction (improved refractories)	24.6 kg CO2/ton clinker	206.0	There can be considerable heat losses through the shell of a cement kiln, especially in the burning zone. The use of better insulating refractories (for example Lytherm) can reduce heat losses. The choice of refractory material depends on the combination of raw materials, fuels and operating conditions.
6	Energy management and process control systems	16.6 kg CO2/ton clinker	157.8	Heat from the kiln may be lost through non-optimal process conditions or process management. Automated computer

No. *	Technology	Typical CO2 Emission Reduction Potential **	CO2 Emission Reduction Potential in 16 surveyed plants in Shandong (kton CO2)	Notes
	in clinker making			control systems help to optimize the combustion process and conditions. Improved process control will also improve product quality and grindability, for example reactivity and hardness of the produced clinker, which may lead to more efficient clinker grinding. A uniform feed allows for steadier kiln operation, saving on fuel requirements.
7	Replacing a ball mill with vertical roller mill in raw materials grinding	10.5 kg CO2/ton clinker	165.0	Roller mills employ a mix of compression and shearing, using 2-4 grinding rollers carried on hinged arms riding on a horizontal grinding table. The energy intensity of vertical roller mill is lower than the ball mill.
8	Adjustable speed drives	9.4 kg CO2/ton clinker	152.0	Most motors are fixed speed AC models. However, motor systems are often operated at partial or variable load. Also, in cement plants large variations in load occur. Within a plant, adjustable speed drives (ASDs) can mainly be applied for fans in the kiln, cooler, preheater, separator and mills, and for various drives.

Notes:

*Measures are ranked by per unit emissions reduction potential; total emissions reduction potential depends on extent of application.

** An emission factor for grid electricity of 1.028 kg CO2/kWh in 2008 in Shandong, China is used to calculate the CO2 emission reduction from electricity saving.

*** Measures number 3 and 4 of the commercialized energy-efficiency technologies are alternative measures. That is, either vertical roller mill should be installed in place of ball mills (usually applied to older ball mills) or a high pressure roller press should be added as the pre-grinding to the ball mill (usually applied to ball mills that are new).

Appendix 7: Data Reporting and Monitoring of Industrial Energy-related Data in China

Energy Statistical Reporting System

China's National Bureau of Statistics (国家统计局, NBS) established the *Energy Statistical Reporting System* (能源统计报表制度) to collect data on energy production, imports, exports, consumption, purchase, inventory as well as energy efficiency nationally and regionally (NBS, 2009).

A common framework of the *Energy Statistical Reporting System* with required reporting items has been established by NBS for provinces to adopt, in order to ensure consistency in statistical methodologies, calculation methods, and statistical scopes.

Four main components are in the *Energy Statistical Reporting System*, including comprehensive annual reports (综合年报表), comprehensive periodic reports (综合定期报表), local-level annual reports (基层年报表), and local-level periodic reports (基层定期报表). Annual reports usually include more indicators than the periodic reports, with wider statistical scopes and more detailed categories. Periodic reports demand quick turn-around time of data collection, i.e., quarterly or monthly data reporting, but target fewer indicators. Both annual reports and periodic reports have comprehensive and local-level reports. Local statistical bureaus of provinces/cities/municipalities provide the comprehensive reports to NBS directly. The local-level reports are formulated by NBS, but can be supplemented with local conditions.

Local statistical bureaus then distribute the local-level reports to industrial enterprises for data collection. As a result, the system covers almost all energy-related activities in one province or region annually, with emphasis on industrial energy consumption at the local level periodically.

Table 8 shows the required data items under the *Energy Statistical Reporting System* used in Jiangsu Province as an example (reference). Although there are provincial differences depending on their local energy structures, the main data requirements for annual comprehensive reporting include:

- energy balance by fuel (in physical quantity and in standard coal equivalent)
- sectoral energy consumption by fuel (primary energy use and final energy use)
- energy resources (coal, oil and natural gas) production, sales and distribution
- transportation energy consumption by mode
- energy imports and exports by fuel
- electricity consumption by sector
- economic energy intensity (reporting both energy consumption and GDP in fixed-prices)

Local-level data reporting include:

- energy purchases, consumption and inventory at industrial enterprises (by fuel)
- water consumption at industrial enterprises

- energy purchases, consumption and inventory at key energy-using enterprises (by fuel)
- energy consumption of main industrial products

It should be noted that both the Key Energy-Using Enterprises and the Top 1000 Enterprises are covered in the NBS system, since by definition their annual energy consumption is larger than 5,000 tonnes of coal equivalent per year.

Table 8 Template of the Energy Statistical Reporting System

# of Tables	Reporting Items	Reporting Frequency	Statistical Scope	Submitted to	Submission methods
Comprehensive Annual Reports					
P303-1	Energy balance table (physical)	Annually	All (excludes military system)	City/Provincial statistical bureaus	Email by the end of March
P303-2	Primary energy consumption by sector (physical)				
P303-3	End-use energy consumption by sector (physical)				
P303-4	Energy balance table (standard coal)				
P303-5	End-use energy consumption by sector (standard coal)				
SP320	Coal production and sales		Local mineral bureaus, coal production companies/groups	Local statistical bureaus	Email or fax by the end of February
SP321	Crude oil, natural gas production and sales		Oil/natural gas extraction groups/companies		
SP322	Crude oil and petroleum products resources and distribution		Petrochemical companies/groups		
SP323	Energy consumption and inventory of transportation and postal services		Railway, air, road and water-transportation companies	Provincial transportation office, provincial communications office, provincial postal office	
SP324	Energy imports and exports		Customs	Local customs	
SP325	Purchase, sales and inventory of petroleum products		Petrochemical companies/groups	Petrochemical companies/groups	
SP326	Energy purchase, consumption and inventory		Provincial construction bureau, fuel companies	Provincial construction bureau, fuel companies	
SP327	Electricity consumption		Power companies	Power companies and power industry associations	
P406	Energy intensity per unit of GDP		Consistent with indicators	City/Provincial statistical bureaus	
Comprehensive periodic reports					
SP420	Energy consumption and inventory of transportation and postal services	Quarterly	Railway, air, road and water-transportation companies	Provincial transportation office, provincial communications office, provincial postal office	Email, submit in 15 days after the end of quarter
SP421	Energy imports and exports		Customs	Local customs	
SP422	Purchase, sales and inventory of		Petrochemical companies/groups	Petrochemical companies/groups	

	petroleum products				
SP423	Energy purchase, consumption and inventory		Provincial construction bureau, fuel companies	Provincial construction bureau, fuel companies	
P407	Electricity consumption	Monthly	Power companies	Power companies and power industry associations	Email, submit in five days after the end of month; for October, submit in nine days after the end of month
Local-level annual reports					
P201	Energy purchase, consumption and inventory of industrial enterprises	Annually	Industrial enterprises	City/Provincial statistical bureaus, power industry associations, petrochemical groups	Email by the end of February
P201-1	Appendix of Energy purchase, consumption and inventory of industrial enterprises		Industrial enterprises that transformed and recycled energy		
P206	Water consumption at industrial enterprises		Industrial enterprises		
Local-level periodic reports					
P201	Energy purchase, consumption and inventory of industrial enterprises	Quarterly	Industrial enterprises	City/Provincial statistical bureaus, power industry associations, petrochemical groups	Email, submit in 12 days after the end of quarter; for the last quarter, submit by Jan 15th
P201-1	Appendix of energy purchase, consumption and inventory of industrial enterprises		Industrial enterprises that transformed and recycled energy		
P201-2	Energy purchase, consumption and inventory of industrial enterprises in key energy-using enterprises	Monthly	Annual energy consumption > 5,000 tce		Email, submit in 12 days after the end of month; for December, submit by Jan 15th; no submission for January
P201-3	Appendix of energy purchase, consumption and inventory of industrial enterprises in key energy-using enterprises		Annual energy consumption > 5,000 tce; Industrial enterprises that transformed and recycled energy		
P206	Water consumption at industrial enterprises	Quarterly	Industrial enterprises		Email, submit in 15 days after the end of 1st, 2nd,

					and 4th quarter; for the third quarter, submit by Oct 20th
P207	Energy consumption per unit of main industrial products	Monthly	Annual energy consumption > 5,000 tce	City/Provincial statistical bureaus	Email, submit in 11 days after the end of month; no submission for January

Source: Jiangsu Government website, valid through June 2010.

Physical energy intensities of main industrial products are collected through the table of energy consumption per unit of main industrial products (主要耗能工业企业单位产品能源消耗情况). It requires enterprises to provide data on both production and energy consumption. The covered products include: coal mining and washing, oil and natural gas extraction, ferrous metals mining, chemical fibers, textile products, paper-making and paper-products, coking, oil refining, inorganic alkali, inorganic salt, ethylene, synthesis ammonia, cement, flat glass, ferrous metal smelting and manufacturing, copper, aluminum, lead and zinc smelting, non-ferrous metal smelting and manufacturing and coal-fired power.

For the data collecting and reporting process, variations occur among different cities and provinces, in data reporting institutes/organizations, reporting methods, and reporting deadlines. However, the basic data reporting procedure is similar across the country.

Figure 17 illustrates the process and structure of the *Energy Statistical Reporting System*, where different energy users/producers report to their corresponding agencies. Industrial enterprises report data on energy consumption, purchases, and inventory to city-level statistical bureaus and industrial associations. Power companies report electricity usage to electricity associations. Mining bureaus and coal-using power companies report their coal production and consumption to city-level statistical bureaus. Oil and natural gas (extraction and refining) companies report production, sales and distribution to city-level statistical bureaus. Transportation sector energy consumption is reported by railway, road and water-transport companies to provincial transportation bureaus. Energy imports and exports are reported by custom entities to provincial customs.

The scope and depth of this system has been expanded with the issuance of three guidelines on the data reporting, monitoring and evaluation systems of economic energy intensity by the State Council in 2007 (《单位 GDP 能耗统计、监测、考核指标体系实施方案》). The guidelines direct the energy data collection to include energy data of small enterprises (规模以下), which have less than 5 million RMB in annual sales, and to cover more types of energy sources, such as renewable energy, low heat-value fuels and industrial wastes. Waste heat and waste energy utilization are also included (State Council, 2007). This expansion of the statistical scope is not only for the industrial sector, which has always been the one of the priorities, but also for the construction sector, public buildings, residential energy consumption, and the tertiary sector (catering and delivering services energy consumption) (State Council, 2007).

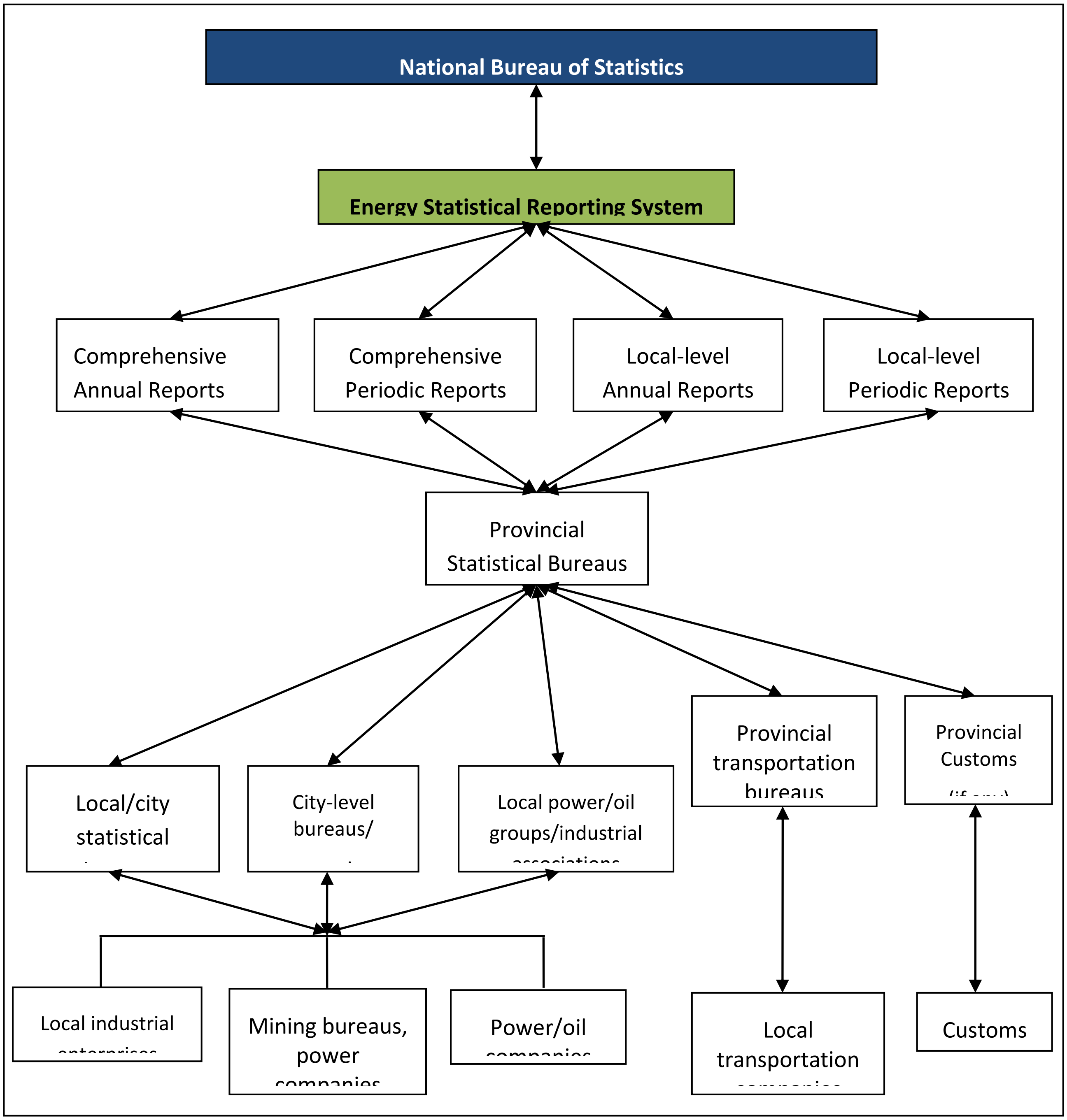

Figure 17 Structure of the Energy Statistical System

Source: NBS, 2009; Jiangsu Government website, 2010.

The *Energy Statistical Reporting System* plays a critical role in China's industrial energy data reporting system. It covers a wide scope of enterprises, including both the Key Energy-Using Enterprises and the Top-1000 Enterprises, which are described in the section below. It tracks important economic and energy indicators, including economic energy intensity, physical energy intensity, as well as specific energy consumption of main industrial products. The yearly outcome of this NBS system is the energy chapters in the national and provincial statistical yearbooks. The *Energy Statistical Reporting System* serves the purpose of understanding the country's situation related to energy consumption and production and helps in evaluating China's progress toward its energy/climate targets at the national level.

However, this system is difficult for NBS to conduct independent evaluation and verification or identify misreported and low-quality data (Sinton, 2001). Because its structure is built by layers upon layers, i.e., NBS depends on the provincial bureaus' provincial data to prepare for the national data, and the provincial bureaus then depend on lower-level entities for data collecting. The quality of the data gathered also largely depends on the coordination and capacities of enterprises, statistical bureaus, industrial associations, and local governmental agencies. Sufficient funding, staff and capacity building for energy statistics are necessary for high-quality data collection and reporting.

This system has paid a great amount of attention to the overall energy situation, but the emphasis on the impacts of specific energy-saving & emission-reduction policies or programs is not sufficient. During the 11th FYP, China established various energy-efficiency programs or energy-saving policies, such as the Top-1000 program or the Ten Key Projects. To analyze the progress and evaluate the impacts of these programs, more public disaggregated data will facilitate programs' development and support making sound policy decisions.

The national-level system currently is more geared toward energy data collecting and reporting, with growing attention on environmental data, such as emissions of greenhouse gases, pollutants and wastes. The Department of Pollution Emission Control of the Ministry of Environmental Protection is taking the lead on the implementation, supervision and verification of the emission-reduction targets. China National Institute of Standardization has completed the draft version of localized ISO standards (ISO 14064-2006) on quantifying, reporting, monitoring and verification of greenhouse gases; and they are working on other ISO standards that are due out in 2011 (ISO/DSI14066: Greenhouse gases -- Competence requirements for greenhouse gas validation teams and verification teams; and ISO 14067: Carbon footprint of products) (AQSIQ, 2009).

Key Energy-using Enterprises

Definition and evolution

In the *Energy Conservation Law of the People's Republic of China* (1997), the Key Energy-Using Enterprises (重点用能单位) were identified as a key area to strengthen energy management in Chapter II Article 20. These enterprises either consumed no less than 10,000 tce annually, or are designated by related governmental authorities with comprehensive energy consumption between 5,000 to 10,000 tce per year (Energy Conservation Law, 1997).

The *Energy Conservation Law* (1997) generally required that energy conservation management agencies at local and national levels supervise and examine the situation of energy utilization in Key Energy-Using

Enterprises (“对重点用能单位的能源利用状况进行监督检查”). Institutions/ companies with certain testing/technical conditions can be commissioned to conduct the examination (Energy Conservation Law, 1997).

The *Energy Conservation Management Regulation of Key Energy-Using Enterprises* (《重点用能单位节能管理办法》) was issued in 1999 by the then State Economic and Trade Commission (SETC, 前国家经济贸易委员会). To supervise the energy management of the Key Energy-Using Enterprises, the regulation set the duties and responsibilities for each level of local economic and trade commissions, and required the SETC and NBS to publish the list of Key Energy-Using Enterprises (annual energy consumption ≥ 10,000tce), as well as annual reports of these enterprises' energy utilization status (SETC, 1999).

In the amended *Energy Conservation Law* (2008), although the definition of the Key Energy-Using Enterprises remained the same as before, they stand out as a separate section (under Chapter 3 Section 6 “重点用能单位节能”). The *Law* explicitly requires the Key Energy-Using Enterprises to complete their annual “energy utilization status reports” (能源利用状况报告), which cover energy consumption, energy efficiency of production systems and equipment, completion situation of energy-saving targets, cost-effective analysis of energy savings as well as implemented energy conservation measures (Energy Conservation Law, 2008). The Law also formulates specific incentives and penalties for both enterprises and institutions that provide energy consultation, evaluation and assessments. This change in the amended *Energy Conservation Law* highlighted that the Key Energy-Using Enterprises became increasingly significantly and thus, have more stringent requirements.

Data reporting system

The data reporting system has been set up for the Key Energy-Using Enterprises to report on their energy utilization regularly with a purpose of tracking, monitoring, managing and evaluating their energy consumption.

Starting in 2008, the National Development and Reform Commission of China (NDRC) established a unified reporting structure for every Key Energy-Using Enterprise to complete. Information required from the enterprises is summarized in the following Table 9.

Table 9 Required data reporting information for the Key Energy-Using Enterprises

# of tables	Data input spreadsheets	Detailed information to report
1	Basic Information	Information on the enterprise, energy managers/staff, economic and energy consumption indicators, and energy consumption per unit of main products
2	Energy Consumption (1)	Purchased energy by fuel, consumed energy by fuel, and inventory
3	Energy Consumption (2)	Energy input and output for transformation, and Recycled/reutilized energy
4	Physical Energy Balance	Energy consumption/losses by process
5	Comprehensive Energy Consumption per Unit of Products	Comprehensive energy consumption of products and year-on-year changes
6	Explanations on factors changing energy/production	Explanations and analyses on key factors
7	Completion of Energy Saving Targets	Tracking the completion of the 11th FYP energy saving goals
8	Evaluation	Self-evaluation on the completion of the targets
9	Main energy-consuming equipment	Overview of energy-consuming equipment (universal and specialized equipment), operation and updates
10	Implementing national standards	Self-assessment of heat, electricity usage
11	List of energy-saving technical renovation retrofits projects	Including project type, name, retrofitted measures, invested capital, time and expected savings
12	Change of energy-saving projects over the last year	Explain the reasons to the changes in energy-saving projects

Source: NDRC, 2008.

These detailed data and information are collected through two channels. One is through a twelve-spreadsheet Excel workbook, which is distributed by NDRC to local governments and then from local authorities to local enterprises. The other is through an online data reporting software, called "The Reporting System for Energy Utilization Reports of Key Energy-Using Enterprises" (重点用能单位能源利用状况报告填报系统). This system was developed by a Chinese IT company, which was commissioned by the NDRC. Enterprises are instructed to either submit their data in electronic copies of the Excel spreadsheets, or fill the tables through this online reporting tool.

To facilitate the process of filling and reporting, positions of energy managers are required to be established within the Key Energy-Using Enterprises and with a notification to related local governmental authorities. The energy managers (能源管理负责人) are responsible for analyzing, evaluating and organizing the composition of the energy utilization status reports. Necessary training on energy conservation is required to become energy managers (Energy Conservation Law, 2008).

Monitoring and Evaluation

When the reports are completed, enterprises are required to submit the reports to local energy conservation management authorities for review and examination by the end of March (NDRC, 2008). As this reporting system was established in 2008, companies were asked to file their 2008 annual reports by March 2009, and at the same time, submit their annual reports for both 2006 and 2007.

Provincial-level governmental authorities are responsible for organizing reviewing reports from larger enterprises (annual energy consumption > 10,000 tce). City-level governmental agencies take the lead in reviewing reports from smaller enterprises (5,000-10,000 tce/year) in their regions, then submit the reports to provincial-level governments.

If certain Key Energy Using Enterprises are found to be low energy-efficient, or have insufficient energy management system, governmental authorities are given the power to conduct onsite investigations, testing the efficiency of their equipment/production systems, require enterprises to conduct energy audits, and provide requirements for modifications in written. Enterprises are required to meet the requirements in a limited timeframe.

According to the amended Energy Conservation Law, the Key Energy-Using Enterprises bear a series of legal responsibilities for submitting the energy utilization reports as well as implementing the instructed modification requirements. The Law stated that if enterprises fail to submit or fail to report the real situation, and did not re-submit their annual reports by their deadlines, companies will be fined in a range of 10,000 RMB –50,000 RMB. If enterprises refuse to implement instructed modifications from the energy management authorities, or their implementations fail to meet the requirements, they will be fine between 100,000 RMB to 300,000 RMB. In addition, if the Key Energy-Using Enterprises did not establish positions for energy managers at their facilities, and further refused to make necessary changes, they will be fined with more than 10,000 RMB, and below 30,000 RMB (Energy Conservation Law, 2008).

With annual status reports from the Key Energy-Using Enterprises of their regions, provincial-governments are directed to prepare an integrated report with reviews and analyses on their regional enterprises' energy consumption and efficiency. By the end of April, integrated reports from provincial governments are required to be submitted to NDRC. The Department of Resources Conservation and Environmental Protection of NDRC will further aggregate the reports at the national level, and publish the national report to the public (NDRC, 2008). The procedures of data reporting for the Key Energy-

Using Enterprises are illustrated in the following

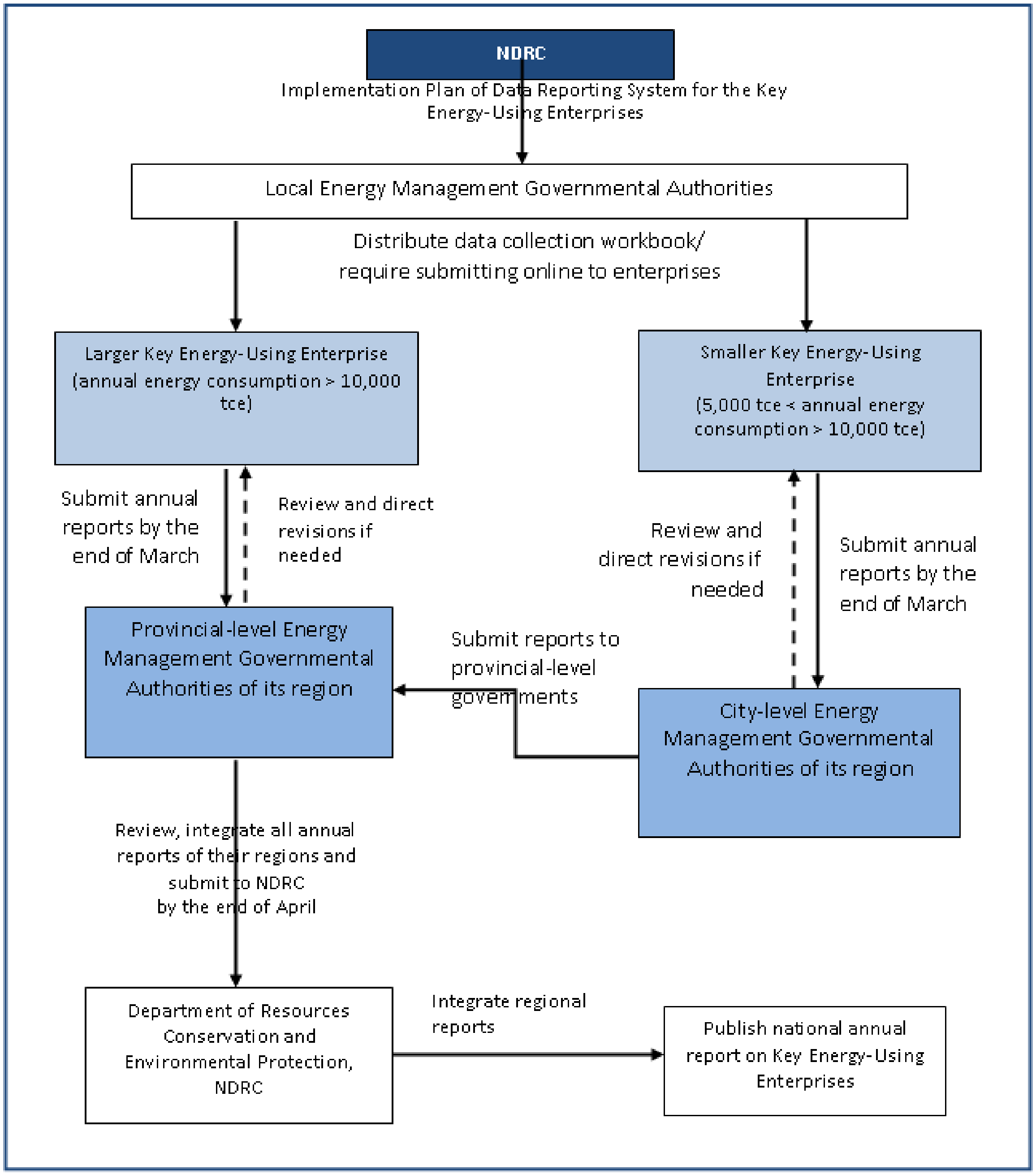

Figure 18.

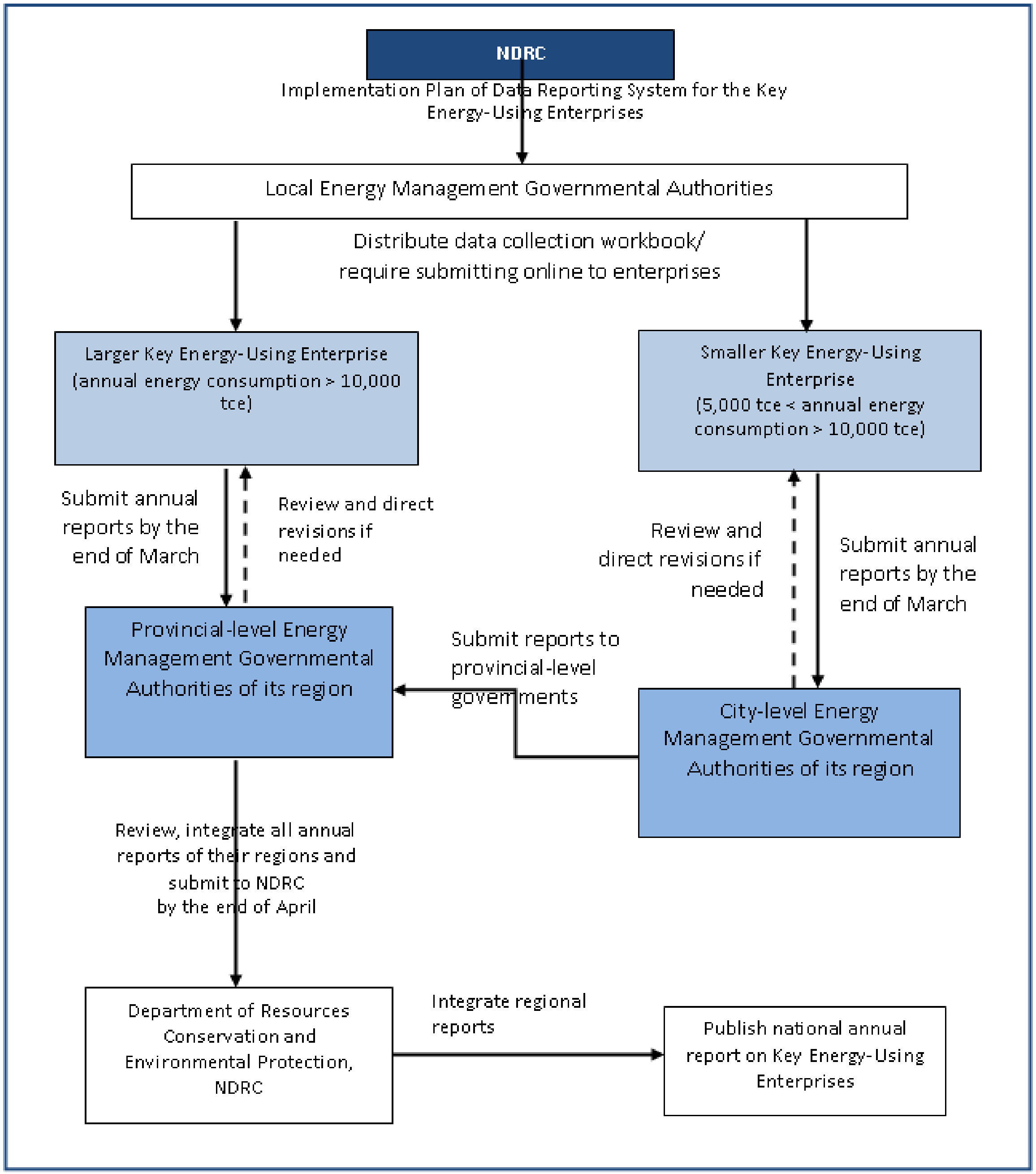

Figure 18 Data Reporting Procedures for the Key Energy-Using Enterprises

Source: NDRC, 2008.

Top-1000 Enterprises

The Top-1000 Energy-Consuming Enterprises Program (千家企业节能行动) was launched in April 2006, to support China's 20% economic energy intensity reduction goal during the 11th FYP. Enterprises in industries of iron & steel, non-ferrous metals, coal, power, petrochemical, chemicals, building materials, textile and pulp & paper, with annual comprehensive energy consumption more than 180,000 tce are targeted under this program. In 2004, there were 1,008 enterprises by this standard (NDRC, 2006). Six tasks for the enterprises have been established under the *Implementation Plan of the Top-1000 Energy-Consuming Enterprises Program* (*Implementation Plan*,《千家企业节能行动方案》), which was announced by NDRC, the Office of National Energy Leading Group, NBS, the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) and the State-owned Assets Supervision and Administration Commission (SASAC). Two of these requirements relate to data collection and reporting: Establish sound energy measuring and statistical system; submit energy utilization status reports of enterprises regularly;

Conduct energy audits and develop energy conservation plans (NDRC, 2006).

Information on enterprises' energy consumption, energy efficiency, cost-effectiveness of energy savings, and energy-efficient measures are required for the energy utilization status reports. The *Implementation Plan* directed NBS should be responsible for organizing and deploying this work.

The Top-1000 Enterprises are also required to undertake energy audits by following the Chinese energy audit standard (GB/T 17166-1997). The *Implementation Plan* would like to use energy audits to analyze the situation on the ground, identify key issues and potentials, and provide feasible and practical energy-saving measures ("通过能源审计，分析现状，查找问题，挖掘潜力，提出切实可行的节能措施"). Based on energy audits, enterprises can formulate their energy conservation plans annually.

In order to track, monitor and evaluate the progress of the Top-1000 Enterprises, involved government entities, including energy conservation authorities at the provincial or local-level, NBS, AQSIQ and SASAC, were designed to take the lead on different tasks, as shown in Table 10 and Figure 19.

For data collection and reporting of the Top-1000 Enterprises in particular, local governments (local energy conservation authorities) supervise and urge the enterprises within their territories, to submit related data and information and conduct regular or random checking on enterprises' energy utilization. NBS of China is responsible for establishing information system of Top-1000 Program and tracking, collecting and reviewing data from the Top-1000 Enterprises. NBS is also in charge of analyzing and integrating the progress of the Top-1000 Program. AQSIQ takes the lead in ensuring the enterprises have the correct and complete measuring equipment. SASAC is focusing on the "central enterprises" (中央企业), whose investment capital is from SASAC, under the commission of the State Council of China. NDRC publishes reports on the progress of Top-1000 Programs, covering the realized energy savings in total and of individual companies. NDRC also organizes verification teams from central governments, research institutions and industrial associations to local provinces to investigate the progress every year in spring.

In addition, industrial associations will assist the target allocation and evaluation system for the Top-1000 Enterprises, research domestic and international best practices of industrial sectors, and provide consultations and training to enterprises in energy-efficient measures and technologies.

Table 10 Duties and responsibilities of governmental entities

Government entities	Responsible for…
Energy conservation authorities at provincial/county/city-level	supervise and urge enterprises to strengthen energy management supervise and urge enterprises to submit information organize experts to review energy audit reports and energy conservation plans supervise and urge the implementation of the plans conduct regular or random checks on enterprises convert targets of reducing energy intensities of products to absolute energy savings allocate energy-saving targets to enterprises promote voluntary agreements and other new mechanisms reward enterprises that meet their targets or reach international best practices
NBS	establish information system for Top-1000 enterprises track, collect and review data organize training on data collection and reporting analyze the progress of the program
AQSIQ	examine the situation of energy measuring instrument/equipment of the enterprises guide the enterprises to establish measuring systems at enterprises urge enterprises to calibrate and adjust measuring instrument instruct enterprise in utilizing the measured data
SASAC	review the performance of the “central enterprises” integrate energy conservation targets into enterprises’ performance reviews
NDRC	Publish Top-1000 Enterprises’ energy utilization status reports Organize verification teams to local provinces

Source: NDRC, 2006.

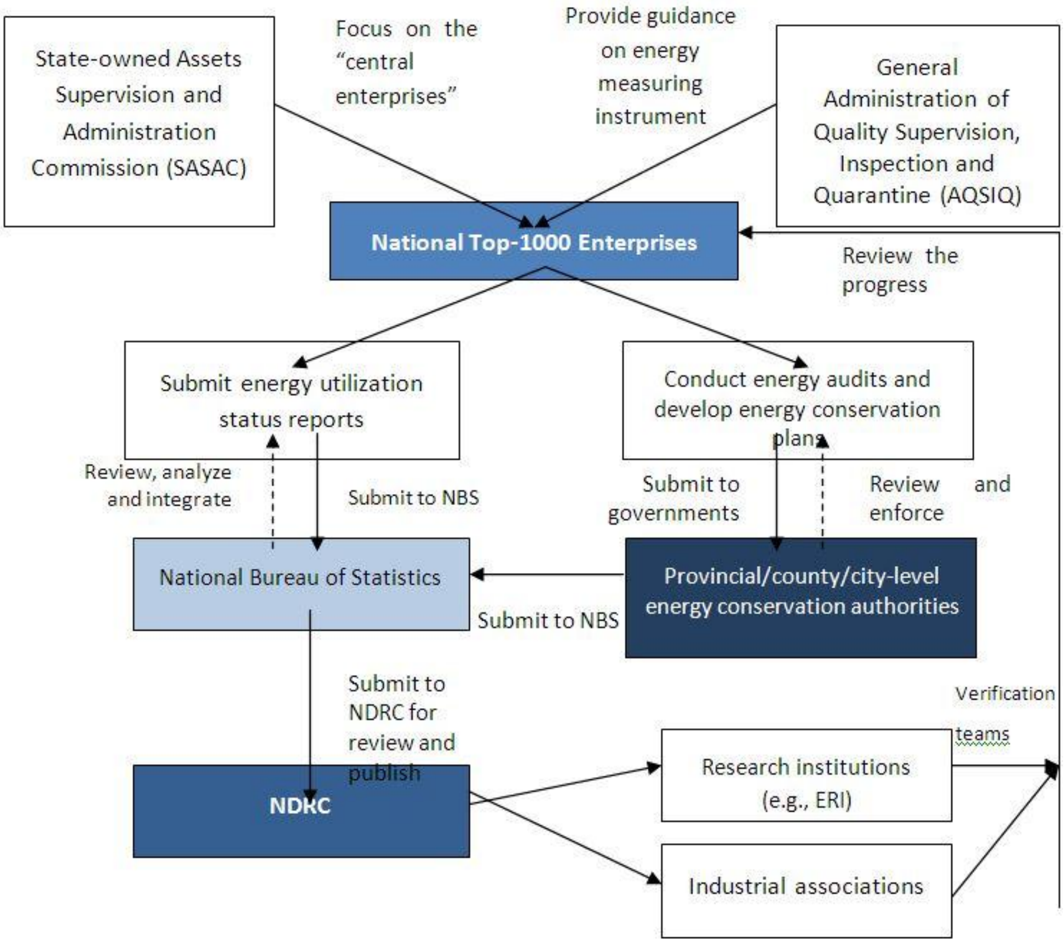

Figure 19 Structure of the Top-1000 Program

Source: NDRC, 2006.

During 11th Five Year Plan energy saving from the programme is reported to be 156 Mtce. However, more detailed information on the program's progress, including progress of energy audits, identified barriers and opportunities are not publicly available. At the program-level, specific information at the company or city-level, could serve the needs of setting up energy conservation baselines, understanding the potentials of energy savings, and designing customized targets for different types of cities and enterprises.

Monitoring and Evaluation

While the number of Top-1000 enterprises in the National Program has decreased from 1,008 in 2006 to 901 by 2009 due to closures, mergers or bankruptcy, the Top-1000 program is expanding at the local level. A number of provinces also established provincial "Top-1000" enterprises. For example, 153 enterprises in Guangdong joined the provincial Top-1000 Program.

The evaluation of Top-1000 Program has two parts. First, enterprises submit reports on their self-evaluation of the completion of energy-saving targets to provincial energy conservation/ supervision centers and provincial Development and Reform Committees, or Economic and Information Committees. Second, provincial governments then convene an evaluation team, with energy experts from industry, associations and organizations, to conduct an evaluation and verification of the self-evaluated reports. Verification results are submitted to local governments as well as NDRC. A scoreboard is developed and used by inspectors to evaluate the performance of Top-1000 enterprises, as shown in Figure 20.

Energy conservation target (40 points maximum)	100% of target achieved: 40 points; 90% achieved: 35; 80% achieved: 30; 70% achieved 25; 60% achieved: 20; 50% achieved: 0
Energy conservation measures (60 points maximum)	Energy conservation leading group: 3 points Energy conservation management department: 2
	Decomposition of target to unit and person 3 Assessment of energy conservation target 3 Reward and punishment system 4
	Energy efficiency performance in 1000 enterprises: 10 for top 10% and 5 for top 50%. Energy conservation R&D fund 4 Annual energy conservation plan 4 Closure of backward equipment 7 Retirement of outdated equipment
	Implementation of local regulation 2 Implementation of energy consumption norm 4 Norm management for energy consuming equipments 2 Implementation of energy conservation design 2
	Energy audit and monitoring system 2 Energy statistics manger and account 3 Energy monitoring appliance 3 Energy conservation training 2

Figure 20 Top-1000 Enterprises Evaluation Scoreboard

Source: Seligsohn, 2010.

Central Stated-Owned Enterprises

In March 2010, a new regulation, "*The Interim Regulation on Energy-Conservation, Emission-Reduction Supervision and Management*" (《中央企业节能减排监督管理暂行办法》) was issued to the Central State-Owned Enterprises (中央企业, or central enterprises). The State-owned Assets Supervision and Administration Commission (SASAC) of the State Council, which has been responsible for supervising the economic performance of the central enterprises, is now given the authority to supervise their implementation of national energy-saving and emission-reduction policies, organize and participate in the energy-conservation evaluation of the central enterprises, and to supervise the establishment of energy-saving management, monitoring & evaluation systems within these enterprises (SASAC, 2010). The central enterprises have been grouped into three categories, based on their energy consumption as well as emitted pollution, as shown in Table 11.

Table 11 Number of and Characterization of Central State-Owned Enterprises

Category	# of Enterprises	Energy consumption	SO2 emissions	COD Emissions
Key Enterprises (重点类企业)	32	>2 million tce per year	>50,000 tonnes per year	>5,000 tonnes per year
Concerned Enterprises (关注类企业)	51	>100,000 tce per year	>1,000 tonnes per year	>200 tonnes per year
General Enterprises (一般类企业)	45	Other central enterprises that are not included in the first two categories		

Source: SASAC, 2010.

The central enterprises are required to set up internal management systems for energy conservation and emission reduction, establish specific energy-conservation and emission reduction plans, and integrate them into corporate development strategies as well as enterprises' annual work plans. The main difference between the "key" and "concerned" enterprises is in the establishment of energy-saving coordination, supervision and management departments. While the "concerned" enterprises are required to have internal agencies established in energy-related departments, the "key" enterprises should have specific functional departments responsible for energy conservation. The attention of "general" enterprises is more focused on the energy-conservation managers or supervisors, who are in charge of energy-related measurements, reporting and analysis.

Monitoring and Evaluation

After the internal management and reporting systems have been put into place, central enterprises are required to evaluate the energy-saving and emission-reduction performance of their sub-companies first, and then submit a summary report to SASAC every three, six and twelve months. Information on companies' energy consumption, emissions of key pollutants, annual changes of energy consumption and pollutants emissions, implemented energy-saving and emission reduction measures, and savings is included in the reports. "Key" and "concerned" enterprises are also required to provide benchmarking results and analysis.

Verification of the submitted reports is conducted mainly by SASAC, through its Audit Office, experts' reviews, onsite examinations, or commissioned third-party institutions.

The "carrot and stick" approach has been used to incentivize central enterprises. Managers of the companies will be down-graded if SASAC finds errors in reported energy data. Managers can get a low score on their performance review if their companies did not achieve their energy-saving targets.

Companies will get SASAC's reward of "Best Enterprise in Energy Conservation and Emission Reduction" (节能减排优秀企业奖)", if they outperformed in energy-conservation and emission-reduction, such as completing energy-saving targets, signing agreements with local governments on energy conservation, having established energy data monitoring and management system, or key energy performance indicators are close to the best practices in China.

Appendix 8: Data requirements for cement plants, California

Category of emissions		Data required	Unit
Process CO_2 emissions from cement manufacturing: two methodologies	Clinker based methodology for CO_2 estimates	Clinker emission factor	Kg CO_2/tonne clinker
		Quantity of clinker produced	tonne
		Lime (CaO) content of clinker	%
		Magnesium Oxide (MgO) content of clinker	%
		Non-carbonate CaO	%
		Non-carbonate MgO	%
		Cement kiln dust (CKD) emission factor	Kg CO_2/tonne clinker
		Plant specifc CKD calcinations rate	Unitless
		Quantity of CKD discarded	tonne
		CO_2 emissions from clinker production	tonne
	Total organic carbon (TOC) content in raw materials	Amount of raw materials consumer in the report year	tonne
		Organic carbon content of raw material	%
		CO_2 emissions from TOC in raw materials	tonne
Stationary combustion emissions		Fuel consumption by fuel type, separately for kiln and non-kiln unites.	Million standard cubic feet for gases, gallons for liquids, short tons for non-biomass solidse, bone dry short tons for biomass-dervied solid fuels
		Average carbon content as a percent by fuel type	
		Average high heat value	MMBtu / fuel unit
		CH_4 emissions factor	kg CH_4 / MMBtu
		N_2O emissions factor	kg N_2O / MMBtu
Fugitive emissions		Coal consumption by coal type	tons
		Emission factor by coal type	SCF CH_4 / tonne
		CH4 emissions from coal storage	tonne
Indirect energy usage		Electricity purchased from each electricity provider	kWh
		Steam, heat and cooling purchases / provider	Btu
		Electricity purchased from each electricity provider	kWh